TECHNOLOGY DEPARTMENT

R

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. XXVII - No. 9 - September, 1948

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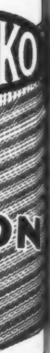

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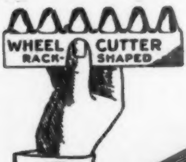

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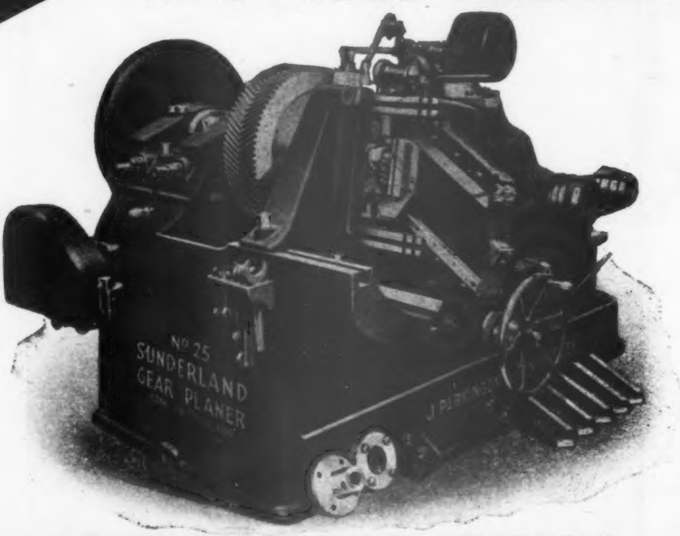

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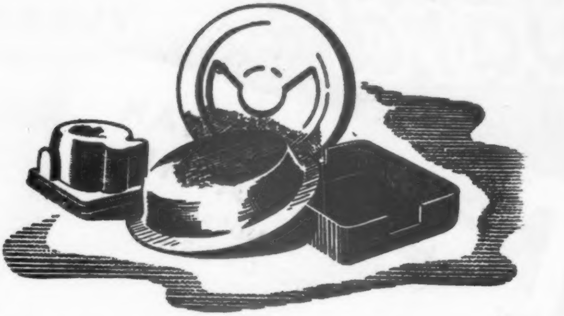

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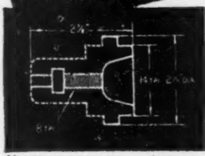
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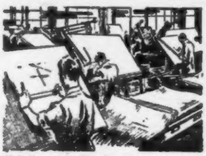
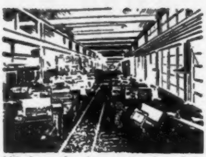

Wickman's engineering service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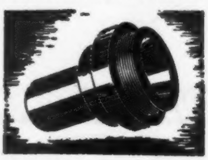

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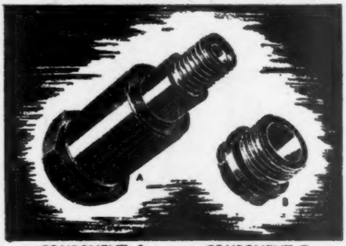

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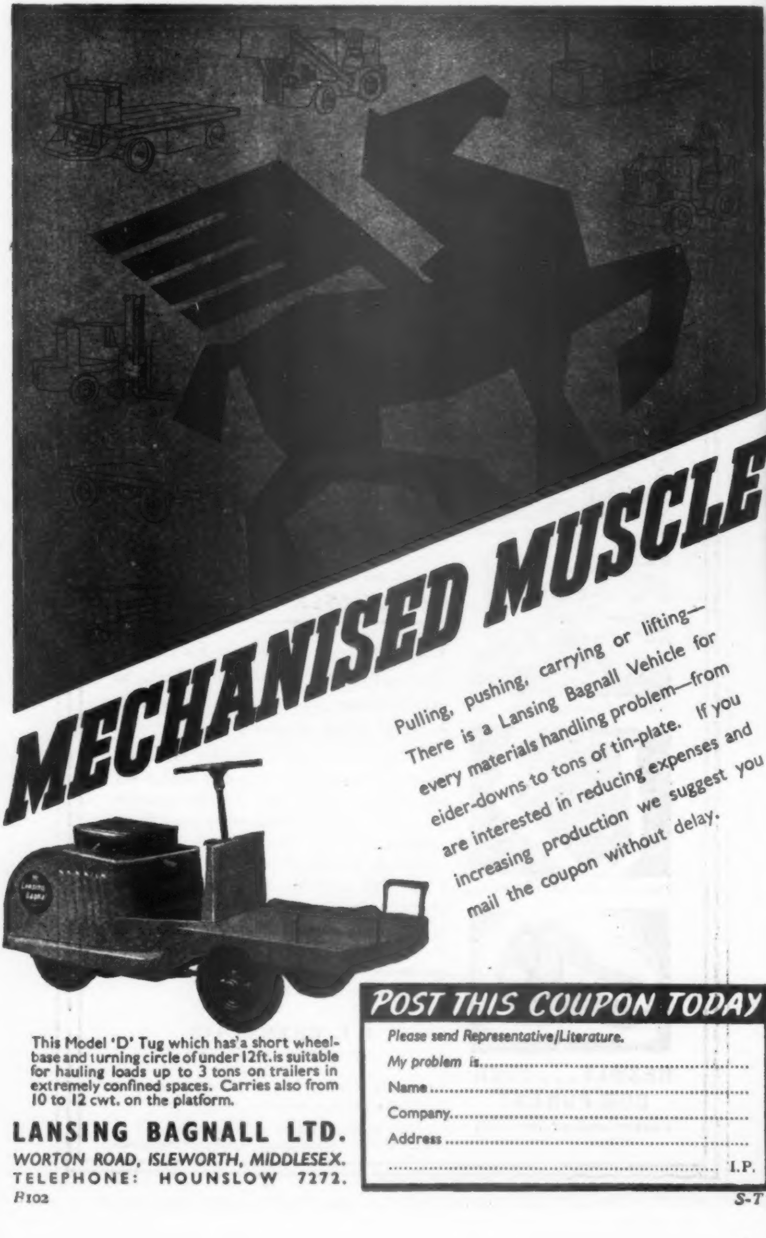
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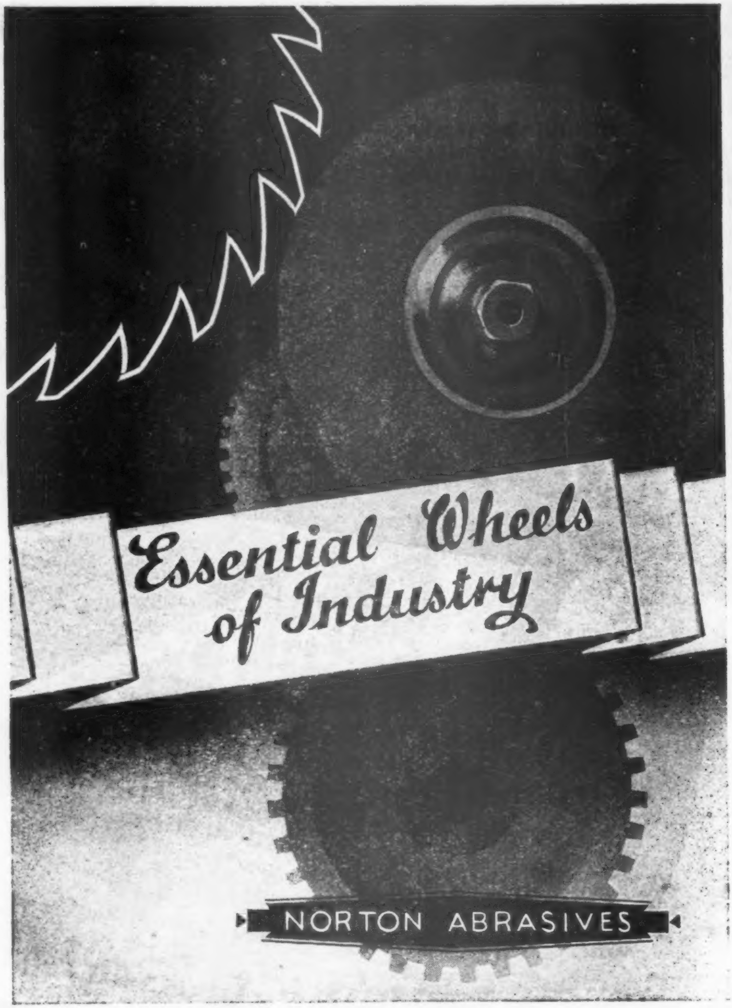

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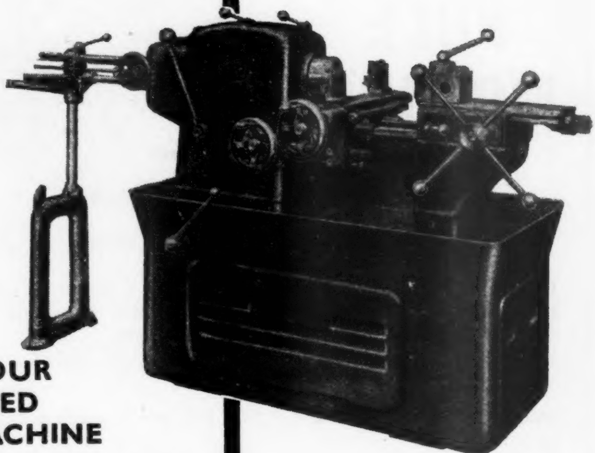

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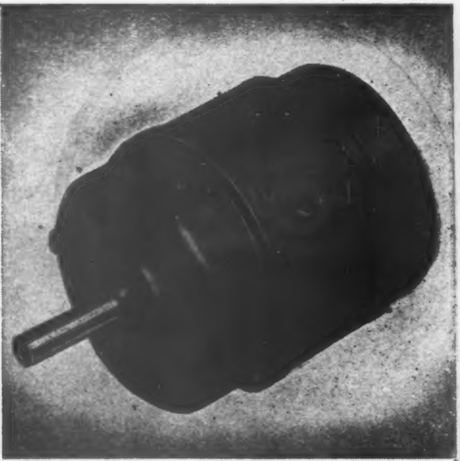

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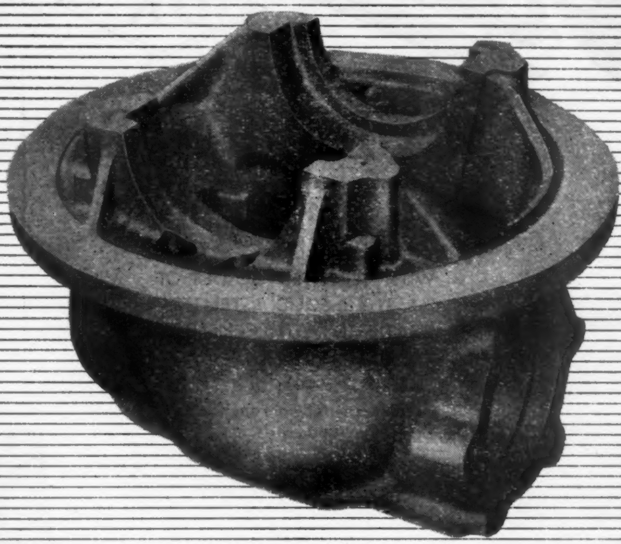

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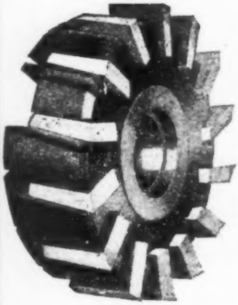

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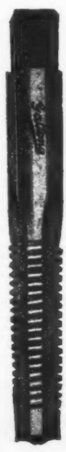

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MR. C. T. SKIPPER, M.I.Mech.E., M.I.P.E.

Institution Personalities — 6.

MR. C. T. SKIPPER, M.I.Mech.E., M.I.P.E.

MR. C. T. SKIPPER, M.I.Mech.E., M.I.P.E.

Mr. C. T. Skipper, Joint Managing Director of Dennis Brothers, Ltd., Guildford, is one of the most notable figures in the commercial vehicle industry. His foresight and enterprise in the years immediately preceding World War II resulted in the foundation of production units which eventually became essential to national survival.

Born in 1891, Mr. Skipper served his apprenticeship with Richard Hornsby & Sons, Ltd., where he studied the fundamentals of the steam, gas and oil feed, prime movers of the day.

During World War I, he served first with the Lincolnshire Yeomanry and then with the Royal Horse Artillery, later volunteering for service with the Royal Flying Corps, where he was accepted as Flying Officer.

In 1919, Mr. Skipper returned to his old firm—now Ruston and Hornsby, Ltd.—where he studied engineering efficiency, planning and organising. Shortly afterwards he joined the Austin Motor Company as an Efficiency Engineer, and foreseeing the impending popularity of the Diesel engine on which he had gained much of his early experience, he entered the commercial vehicle industry.

At the age of 30, Mr. Skipper commenced fourteen years' service with the Leyland Company, as Planning Engineer. He quickly became Production Manager, and in 1931 was appointed Works Manager, in which position he remained until 1936. After planning and building, with the Daimler Company, one of the first production units which was to render such vital service during World War II, in 1938, through the Nuffield organisation, Mr. Skipper was appointed General Manager of the Castle Bromwich aeroplane factory, where he laid the foundations for Spitfire production.

The ultimate outbreak of hostilities found Mr. Skipper lending drive and his wealth of experience to the production of tanks and war transport vehicles as Works Director of Dennis Brothers, Guildford. Three years later he was appointed to his present rank of Joint Managing Director.

INSTITUTION NOTES

September, 1948

COUNCIL MEETING The next meeting of Council will take place on Thursday, October 28th, 1948, at 11.0 a.m., at 36, Portman Square, London, W.1, and will be followed by the Annual General Meeting, at 4.0 p.m.

THE ASSOCIATE MEMBERSHIP EXAMINATION Members of the Institution will be interested to learn that new membership qualifications and examination regulations were approved by Council at a meeting held on July 15th, 1948.

The examination regulations involve the introduction of an Associate Membership Examination in September, 1950. No change in the examination requirements will be made until that date.

The October issue of the Journal will contain a summary and explanatory notes concerning the new examination. The complete scheme is outlined in a publication entitled "Membership Qualifications and Examination Regulations," which may be obtained on application to Head Office.

JOINT CONFERENCE A Joint Conference on "Modern Applications of Liquid Fuels" will be held by the Institute of Petroleum and the Institute of Fuel at Birmingham University on September 21st–23rd, 1948.

The object of the conference is to place the technical considerations involved in utilisation of liquid fuels, at this time, before the fuel-using public, indicating the proper place of alternative fuels in various circumstances.

Full particulars may be obtained from the General Secretary, Mr. R. W. Reynolds-Davies, 18, Devonshire Street, London, W.1.

TECHNICAL EDUCATION *Erith Technical College.* Applications are invited for the post of Lecturer in Mechanical Engineering, including Heat Engines and Applied Mechanics. Applicants should possess graduate or equivalent qualifications and be qualified to teach up to Higher National Certificate standard. Salary will be in accordance with the Burnham Technical Scale, with allowances for teaching and/or industrial experience. Particulars may be obtained from the Principal, Erith Technical College, Belvedere, Kent.

County Technical College, Dartford. Applications are invited for the post of Lecturer in Production Engineering and Engineering Materials. Qualifications in Production Engineering and considerable industrial experience are essential, while teaching experience

would be an advantage. Salary will be on the Burnham Technical Scale with increments for industrial experience and war service. Particulars may be obtained from the Principal, County Technical College, Essex Road, Dartford.

Rotherham Technical College. Applications are invited from Graduates in Engineering for the post of Senior Assistant in the Department of Mechanical Engineering. Candidates should have special qualifications in Production Engineering and have had industrial experience, preferably in heavy industries, while some teaching experience is desirable. The work of the Department ranges from Ordinary National Certificates to full-time courses for External Degrees of London University. Salary will be in accordance with the Burnham Scale for Senior Assistants—£700 × 25—£800. Particulars may be obtained from the Director of Education, Education Offices, Rotherham.

BRITISH STANDARDS INSTITUTION The following draft B.S. Specifications have been prepared by the B.S.I. Committees indicated, and are now available for comment. Copies can be obtained gratis from the British Standards Institution provided that mention is made in the letter of application that the writer is a member of the Institution of Production Engineers :

(*a*) CJ(PSM)6370—Draft British Standard for fire-resistant clothing for industrial purposes.
Prepared by Committee PSM/8.
The Institution is represented on this Committee by Mr. F. Southwell, M.I.P.E.
Latest date for receipt of comments : 10.9.48.

(*b*) CJ(MEE)7186—Draft British Standard for Press Tool Sets.
Prepared by Committee MEE/97.
The Institution is represented on this Committee by Mr. L. E. Brookes, M.I.P.E., and Mr. W. H. Estall, A.M.I.P.E.
Latest date for receipt of comments : 5.10.48.

ANNUAL SUBSCRIPTIONS Members are reminded that annual subscriptions for the financial year 1948–49 fell due on July 1st, 1948. Payments should be made to Head Office as soon as possible.

NEWS OF MEMBERS

Mr. C. C. Bailey, M.I.P.E., is now General Manager and Director of Duple Motor Bodies, Ltd., Hendon.

Mr. S. Davey, A.M.I.P.E., is now Planning Engineer in charge of the Isotopes Division of the Ministry of Supply Department of Atomic Energy at Risley, near Warrington.

Mr. G. A. Firkins, F.C.W.A., M.I.P.E., has resigned from the Board of Midland Industries, Ltd., Wolverhampton, and has set up in practice as a Consulting Engineer.

Mr. M. W. Hall, Int.A.M.I.P.E., has been appointed Works Manager of National Machinery Manufacturers, Ltd., India.

Mr. C. J. Martin, Grad.I.P.E., has joined The Boot & Shoe & Allied Trades Research Association, Kettering, Northants, as Production Engineer and Industrial Investigator.

Mr. G. F. N. Martin, A.M.I.P.E., A.M.I.Mech.E., formerly Production Manager at Messrs. Carpet Trades Ltd., Kidderminster, is now Director and General Manager of Messrs. Wm. C. Gray & Sons, Ltd., Carpet Manufacturers, Ayr.

Mr. Ian McLeod, A.M.I.P.E., has taken up an appointment with Messrs. Premier Colloid Mills, Ltd., London, where he is in charge of Design and Production.

Mr. J. L. Ramsey, A.M.I.P.E., is now Development Engineer with Watliff Co. Ltd., Wimbledon.

Mr. J. E. Williams, A.M.I.P.E., recently became Works Manager of Ranalah Yacht Yard, Ltd., Isle of Wight.

Mr. Arthur Wood, A.M.I.P.E., has been appointed Managing Director of C. E. Johansson, Ltd., Dunstable.

VISITORS FROM ABROAD Mr. J. H. Blunt, M.I.P.E., Hon. Treasurer of Sydney Section, and Managing Director of Alfred Herbert (Australasia) Pty. Ltd., Sydney, is on a visit to the parent company at Coventry, where he served his apprenticeship. He was afterwards engaged in all phases of machine tool work, including the starting up of plants for the production of various components.

Mr. J H. Blunt

The object of Mr. Blunt's visit is to investigate the latest methods of production and latest types of machine tools.

Mr. R. H. Davis, A.M.I.P.E., also of Sydney Section, has come to the United Kingdom to investigate new and improved methods of making builders' hardware and to

Mr. R. H. DAVIS

re-equip his toolroom and production shop. After learning the trade of toolmaking in the London area, Mr. Davis went to Australia in 1926 and started his own business two years later. He is now General Manager of Osborn Pressed Metal Works, Narrickville, N.S.W., which specialises in the mass production of builders' hardware.

While over here, he hopes to attend the Institution's Convention at Bournemouth and the Machine Tool Exhibition in London.

OBITUARY The Institution has suffered a grave loss in the sudden death of a Founder-Member, Mr. R. H. Youngash, M.I.P.E., who served for many years on the Council of the Institution.

Mr. Youngash started his engineering career with Messrs. White & Poppe, Ltd., following which he joined the Lanchester Motor Co., and later Messrs. J. T. Thornycroft & Co. Ltd. He went to the Austin Motor Co. Ltd. as Machine Shop Superintendent in 1918, and remained with this company until his retirement in June, 1946.

Mr. Youngash will be remembered for his untiring work on the Membership and Education Committees, of which latter Committee he was elected Vice-Chairman in 1947, and he will be greatly missed by his many friends in the Institution.

The Institution also deeply regrets to announce the deaths of the following members : Mr. W. H. J. Stockley, A.M.I.P.E., of London Section, following a long and painful period of ill-health which he endured with great courage and fortitude ; Mr. William Hall, M.I.P.E., of Luton Section and Mr. E. O. Schreiber, M.I.P.E., of London Section.

LORD AUSTIN PRIZE, 1948

Conditions of Award

(*a*) Graduates up to the age of 28 years are eligible to enter for the Lord Austin Prize, but may only be *awarded* the prize once during their term as Graduates.

(*b*) Closing date for entries will be September 30th, 1948. Essays should be sent to Head Office.

List of Subjects

1. Mechanical Handling.
2. Developments in Fine Measuring.
3. Application of Production Techniques to one non-engineering industry.
4. Work Measurement.
5. Economics of Jig and Tool Design.

BOOKS RECEIVED " Dimensional Analysis of Engineering Design ", Vol. 1—Components (Part I). Published by H.M. Stationery Office. Price 7s. 6d. net.

A scientific analysis of the method of correct dimensioning and use of tolerances is contained in this publication, which covers the work of an Interservices Committee to establish a basis and a method of application of a system of tolerancing and dimensioning engineering drawings. The work is fully illustrated, covering a wide field of engineering practice.

The Committee consisted of prominent members of the Ministry of Supply, D.S.I.R., Admiralty, M.A.P., and other co-opted members under the chairmanship of Mr. F. H. Rolt, O.B.E., M.I.P.E.

This manual covers, in a scientific manner, the method of dimensioning drawings. The reasoning is logical and to the point, and the experienced designer could find little in the text to quarrel with, and would no doubt be working on the lines recommended in the majority of cases. The publication should be included in all technical libraries, including technical schools, and should form the basis of the course of draughtsmanship of all technical colleges.

Application of the principles advocated would eliminate a large proportion of the fitting difficulties which sometimes occur as a result of loose dimensioning, and if widely applied would be a step towards greater national efficiency. A.A.F., M.I.P.E.

" Management—Its Nature and Significance " by E. F. L. Brech, B.A., B.Sc.(Econ.), M.I.I.A. Sir Isaac Pitman & Sons, Ltd., London. Price 8s. 6d. net.

" Aircraft Development and Production ", Vol. I. Edited by G. W. Williamson, F.R.Ae.S., M.Inst.C.E., M.I.A.E., and M. M. Williamson, F.R.S.A. Paul Elek Publishers, Ltd., London. Price 30s. net.

" Electric-Motor Control Gear " by J. L. Watts, A.M.I.E.E. Electrical Review, Ltd., London. Price 5s. net.

ISSUE OF JOURNAL TO NEW MEMBERS Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

SECTION MEETINGS

The following meetings have been arranged to take place in September, 1948. Where full details are not given, these have not been received at the time of going to press.

September

2nd NOTTINGHAM SECTION. A visit has been arranged to the Standard Motor Co. Ltd., Coventry, to inspect production of agricultural tractors, starting at noon.

7th COVENTRY GRADUATE SECTION. A lecture on "Automatic Turning Machines" will be given by Mr. R. F. Eaton, Grad.I.P.E., in Room A5, Coventry Technical College, at 7.15 p.m.

9th WOLVERHAMPTON GRADUATE SECTION. A lecture on "Foundry Practice", illustrated by lantern slides, will be given by Mr. E. L. Graham at the County Technical College, Wednesbury, at 7.15 p.m.

GLASGOW SECTION. A Works Visit has been arranged to Messrs. Anderson Boyes & Co. Ltd., Motherwell, at 6.30 p.m.

10th LIVERPOOL SECTION. The Inaugural Dinner, at which the principal guest will be the Rt. Hon. J. Harold Wilson, O.B.E., M.P., President of the Board of Trade, will be held at the Adelphi Hotel, Liverpool, at 6.30 for 7.00 p.m.

11th LEICESTER SECTION. A visit has been arranged to the Machine Tool Exhibition at Olympia, London.

13th MANCHESTER GRADUATE SECTION. A lecture on "The Lost Wax Process" will be given by Mr. A. Short, Grad.I.P.E. in Reynolds Hall, College of Technology, Manchester, at 7.15 p.m.

14th BIRMINGHAM GRADUATE SECTION. A film show entitled "The Romance of Carborundum" will be given at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.00 p.m.

15th BIRMINGHAM SECTION. A lecture on "Difficulties and Developments in Deep Drawing and Pressing" will be given by Dr. J. D. Jevons, B.Sc., F.R.I.M., F.I.M., in the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.00 p.m.

September—*cont.*

17th N.E. GRADUATE SECTION. The Chairman's address will be given at the Neville Hall, Newcastle-on-Tyne, at 6.30 p.m.

20th DERBY SUB-SECTION. A lecture on " The Production Engineering Research Association of Great Britain " will be given by Dr. D. F. Galloway, B.Sc.(Hons.), M.I.P.E., at the Art School, Green Lane, Derby, at 7.00 p.m.

20th N.E. SECTION. A lecture, " Modern Milling Practice," will be given by J. Henderson at the Neville Hall, Newcastle-on-Tyne, at 6.30 p.m.

27th MANCHESTER SECTION. A lecture on " Production Research and Development in America " will be given by Dr. H. Orenstein, M.I.Mech.E., M.I.P.E., at the Manchester College of Technology, Sackville Street, Manchester.

29th BIRMINGHAM SECTION. A lecture on " Education for Management " will be given by Lt.-Col. L. Urwick, O.B.E., M.C., M.A., M.I.P.E., at the Chamber of Commerce Building, New Street, Birmingham, at 6.30 p.m.

29th MANCHESTER SECTION. A lecture on " Some Practical Aspects of Gas Turbines " will be given by T. L. Gardner at the Mechanics' Institute, Crewe.

ELECTION OF MEMBERS

MEETING OF COUNCIL, 15th JULY, 1948

The following were elected to membership by Council :—

As Members :

R. W. Asquith, C. O. Doehring, S. Downie, B. F. Goodchild, D. A. Fairnie, H. J. G. Goyns, G. Hayes, A. J. Hudson, O. Morgenstern, Y. E. H. Norel, M. Perrin, B. Pugh, A. Robson, R. N. Saxby, J. W. Swardt, J. Thorpe, F. G. Woollard.

As Associate Members :

W. O. Bell, R. S. Bevan, C. V. O. Binding, W. A. Bottrill, E. de Renzie Brown, T. E. Bunker, A. N. Clements, C. Downs, C. G. Duce, D. S. M. Eadie, J. L. Fromson, F. Hodgkinson, W. P. Honigmann, J. B. Hulme, T. W. Ivison, W. J. Izzard, M. H. Ketteridge, G. A. Luff, J. A. C. McIntosh, W. G. Middleton, F. M. Nash, J. H. O'Sullivan, G. F. F. Ottley, F. H. Packwood, P. J. Papworth, N. E. Parks, E. I. Perry, G. Robertson, A. L. Rushton, L. J. Service, J. R. Shaw, J. V. Shah, J. D. Scott, K. Smith, W. U. Snell, A. L. Taylor, J. H. Taylor, E. G. Thomas, J. A. Whalley, E. K. Wilde, A. Williams.

As Intermediate Associate Members :

F. R. Carne, R. Cashmore, S. N. Chatterjee, C. L. Clarke, J. D. Darroch, J. Dickson, E. S. Dodd, R. E. Green. A. G. Griffiths, S. S. Goldthorpe, F. W. James, K. C. Jeavons, H. Jennings, O. C. S. Kallay, V. P. Kaura, W. P. N. Kirk, W. A. P. Lewis, A. E. Long, D. H. Ludlam, G. Malugani, A. B. Marshall, A. J. Milburn, J. Ofchinsky, P. J. O'Leary, M. S. Patra, K. Vishwanath Rao, W. Reason, B. W. Rogers, S. S. Satsangi, F. G. Smith, H. J. Stanley, A. G. Thorburn, A .Tresham, J. T. Turner, S. Upton, J. Wilkinson, C. A. Whitford, W. Young.

As Associates :

A. R. Chapman, A. Eustace, M. G. Goold, W. E. Harrington, H. J. Robins, C. S. Watters.

As Graduates :

R. Ball, V. A. Bavington, R. E. Blaby, L. Bonner, A. W. Caughey, W. S. Forster, G. B. Gadre, W. R. Hall, L. W. Hampton, E. Jackson, D. J. Jerrard, B. Kemp, M. H. A. Kempster, J. A. Lane, H. K. Lawrence, D. L. McNamara, M. C., E .R. S. Marrs, E. H. Mitha, A. J. Munro, J. C. Nijhawan, K. A. Norton, K. R. Ralphs, D. Selby, P. R. Smith, S. D. Taylor, G. C. R. Vaughan, J. H. Weaver, D. A. F. White, C. W. Whitehead, P. A. Wibrow.

As Students :

J. J. Adams, A. G. Allsop, F. Davenport, M. D. Drinkwater, D. L. Evans, H. H. Fletcher, R. D. Gutrie, A. Hindmarch, G. Ingram, P. G. Jenkins, I. Jones, W. R. Kelly, A. W. Lockwell, J. P. Mabon, W. Pollard, B. E. Sherwood, R. C. Short, J. Singh, R. H. Tobia, P. E. Varvell, E. Walker, D. W. Whittaker, J. Wylde.

Affiliated Firm	Change of Affiliated Rep.
Bristol Aeroplane Co. Ltd.	R. S. Brown

TRANSFERS:

From Associate Member to Member:

N. E. Allender, D. Bailey, E. Bernfeld, L. Bunn, N. A. Cullin, H. H. Dawson, T. A. Kestell, R. N. Line, J. R. Lowe, R. L. Paice, G. H. Rogers, G. V. Stabler, F. Whitehead.

From Associate to Member:

W. J. Vaughan.

From Graduate to Member:

B. R. Gimson.

From Intermediate Associate Member to Associate Member:

D. N. S. Clare, J. Geddes, R. J. Heppenstall, G. Keeble, W. J. Latty, T. W. Leech, J. North, G. H. Parlor, R. A. Powley, H. Sampson, J. C. Sharman, N. S. Smith, R. Wildey, H. J. Wright.

From Graduate to Associate Member:

K. G. Adcock, E. Darwin, W. I. Day, H. C. Dyer, H. J. Elmore, G. Fooks, K. W. Hinds, T. C. Hugill, F. C. Knott, C. J. Martin, B. P. Smith.

From Student to Associate Member:

W. S. J. Grant.

From Graduate to Intermediate Associate Member:

A. F. King.

From Student to Intermediate Associate Member:

L. R. Houghton.

From Students to Graduates:

A. E. R. Chambers, J. A. Cleal, J. J. Dyer, D. Graham, J. H. Graham, R. J. Hall, M. R. Harvey, D. R. G. Nash, J. Rook, E. W. H. Scaife, G. C. Smith, A. J. Storey, S. R. Tyler.

ENGINEERING ABSTRACTS

Many requests have been received from members for the continuance in the Journal of Engineering Abstracts, which in the past were prepared by the Institution's Research Department.

Since the formation of the Production Engineering Research Association of Great Britain as an entirely independent body, the Institution has not had access to the abstracts, which P.E.R.A. now sends only to its own subscribing members.

The Technical and Publications Committee is actively considering ways and means of resuming the service for members of the Institution. It is essential that these abstracts should be prepared by experienced engineers and the work cannot be undertaken by the present staff at Headquarters. The Institution therefore asks for volunteers from among members to express their willingness to act as external honorary correspondents to the Technical and Publications Committee to co-operate in this work. At the same time it would be appreciated if members who are willing to undertake the preparation of abstracts would state if they have any preference for a particular Journal and whether they already subscribe to it or would wish the Institution to provide it.

The Technical and Publications Committee would like to extend this scheme to cover book reviewing and members who are willing to assist should specify their subject. For the guidance of those willing to join in the scheme, the following notes have been prepared by the Education Officer.

NOTES FOR GUIDANCE These notes have been prepared so that abstracts from articles of managerial or technical content may be made readily and with a reasonable degree of standardisation.

1. Abstracts should be prepared of all articles containing information useful in the practice of production engineering in its widest sense. The abstracts will thus fall under the main headings of management, technique and education.

2. Since the purpose of an abstract is to present essential information concisely, brevity is essential. Thus every word in the abstract should do its share in this respect. Mathematical data should be avoided, only essential sizes and figures should be given.

3. All abstracts should comprise a single paragraph of not more than ten lines, and should be impartial. Unlike a review, the opinion of the writer is not required.

4. Abstracts are only required from articles which contain comparatively new information, such as a new application of a

recognised management technique or of an established technical procedure. Alternatively, the article may contain information of a completely new technique or details of the properties of a new material.

5. The exception to the last note is where information is presented in an exceptionally convenient form not previously published.

The following examples may serve to illustrate the application of such notes for guidance.

Example 1.—MANAGEMENT

Size of organisation and efficiency

"Industry" for June, considers this question in the light of a report by an American Select Committee. It is pointed out that their conclusions might be considered to advantage with reference to industry in this country.

Example 2.—EDUCATION

Mathematics laboratories

The "Higher Education Journal" for June contains an article on mathematics laboratories, justifying their establishment by a critical survey of teaching methods.

Example 3.—TECHNICAL

Aluminium Alloy Casting Developments

The "Machinist" for July 3rd, gives details of the use of aluminium castings in Machine Tools and Building, and outlines the factors affecting the choice of alloy. A useful bibliography is included as well as notes on cost and durability.

T. B. WORTH

VARIOUS ASPECTS OF INSPECTION OF PRODUCTION *

by B. McMAHON, M.I.P.E.

Presented to the Halifax Section of the Institution, March 15th, 1948.

In discussing the development of systems of measurement for use in manufacturing processes, one should try to visualise the driving force behind it. It is the law of progress that there is no saturation point in the world demand for increased social amenities, and cheaper and better comforts and it is paradoxical that the engineer must have and adopt more efficient methods of measuring and manufacture, improved layouts, good tools and better tooling and improved methods of material handling to cheapen commodities and bring them within the reach of the greatest number.

If industry is to be successful, it must be self-supporting. Industry is essential to support life ; for payment of wages to be continuously possible, they must be provided out of the products of industry and for wages to be high and have a standard of purchasing power, the most efficient methods of production must be devised.

Wealth in the form of articles which have a utility value must be produced and sold at prices which attract customers, and must embody the socially necessary labour time. There is today a greater demand for the natural mineral resources of the world to be exploited, due to the emergence, in lands that have been for centuries living under primitive conditions, of men desiring to have access to social amenities which the advancement of science and art and man's inventive genius have made possible.

ANCIENT STANDARDS The solution of this problem has exercised the best intellects in all countries, particularly so since the commencement of the industrial era and the introduction of the steam engine. Whilst it is acknowledged that definite standards of measurement existed in ancient times, it is a fact that during the 15th and 16th centuries three barley corns round and dry were the standard of length for one inch. The work of establishing common standards of measurement introduced sense and integrity into commercial transactions, making possible the marketing of productive machinery to many parts of the world.

World wide standards of manufacture and testing would result in the development of a set of yardsticks whereby the standards of one country could be compared with those of another, and expressed in

* *Common Subject 1947/48.*

The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any papers published in the Journal of the Institution.

definite numerical relationships. According to a well-known electrical engineering firm, international trade in electrical goods is often handicapped because of the varying standards of the countries involved. In measuring work, many different gauges and appliances are used, from the simple caliper and scale to the very high order of reference gauges and measuring machines now available.

It would be well at this stage if a brief outline was given of the history and development of the different standard units of length, the imperial yard and the international metre.

The imperial yard is the principal unit of length in the United Kingdom, British Colonies and the United States and was originally represented by the distance in a straight line between the centres of two points marked on gold studs inserted in a brass bar made in 1760, and kept in the custody of the British Government.

THE STANDARD YARD By an Act of Parliament of June 17th, 1824, this was declared to be the standard imperial yard at a temperature of 62° F; Section III of the Act mentioned wisely provided that if the bar defining the standard imperial yard became lost, destroyed or otherwise injured, the same length should be re-established by reference to an invariable natural standard, this being the length of a pendulum vibrating seconds of mean time, in a vacuum at sea level in the latitude of Greenwich.

The Act declared that such a pendulum, when compared with the standard imperial yard, had a length of 39.1393 inches.

On October 16th 1834, both Houses of Parliament were destroyed by fire, the standard yard being hopelessly damaged. In the period of ten years which had elapsed, investigations had been conclusive that the determination of the ratio of the length of the standard yard to the seconds pendulum was inaccurate, so much so that all attempts to reproduce the standard by reference to the seconds pendulum had to be abandoned. It was then decided to construct a new standard yard by reference to copies that had been made.

The first man to be entrusted with this work was Sir Francis Bailey. As the result of much experience he had decided on an alloy composed of :—

Copper	16 parts
Tin	$2\frac{1}{2}$,,
Zinc	1 part

This alloy is still known by the name of "Bailey's Metal". This gentleman unfortunately died before its completion. The restoration work was finally completed by the Rev. R. Sheepshanks. It is known as Bronze No. 1 and is made from Bailey's Metal being 38" long, 1" square and has two gold plugs inserted with defining lines across the plugs 36" apart. The use of this standard unit of length was legalised in 1855 by Act of Parliament.

THE METRIC STANDARD The Metric Standard is founded on the French metre which is the length of a platinum bar at 0° C. kept in Paris. When it was made it was supposed to be $\frac{1}{10,000,000}$ of the quadrant on the meridian at Paris, but it is about $\frac{3}{20,000}$ shorter than it ought to have been ; to compare accurately with this quadrant it is equal to 39.37 inches.

It may be added that although copies of the imperial standard yard were presented to the U.S. Government in 1856, it had never been formerly legalised in the United States.

The International Bureau of Weights and Measures had several copies of the standard metre made in 1889, and presented them to the United States and other Governments. The legal equivalent of the metre was fixed by law in 1866, as 39.37 inches and the United States Bureau of Standards was authorised by Executive Order in 1893 to derive the yard from the metre by the use of this relation. Metric length measures are standard at 20° C. and standards in units of the yard are made to be correct at 68° F.

More definite means of reference are being used which have not yet been legalised. Cadmium light waves were used by Professor Rogers and William Bond, of the Pratt and Whitney Co. of America during the development of the manufacture of gauges by that company and gauges are procurable which use helium light waves as a means of measuring standard reference gauge blocks.

BLOCK GAUGES The system in vogue in the various arsenals and gun factories were the use of the block gauges and length gauges for the accurate production of gun and rifle parts during the past 100 years.

The Johansson system of reference blocks was developed by C. E. Johansson, a foreman in the Swedish arsenal. Owing to the extreme accuracy to which these gauge blocks are made, they are used for inspection and for manufacturing purposes. The combination consists of a series of rectangular blocks, which are made from nickel steel carefully machined, seasoned, ground and lapped on all sides. The opposite sides of each are parellel and the distance between them is equal to the dimensions stamped on them within a maximum tolerance of $\frac{1}{100,000}$ of an inch. With a set of 81 blocks used with the standard plugs and holder for retaining these blocks over 100,000 different internal and external gauges are obtained. The contacting surfaces are carefully cleaned with chamois skin and then the gauges are slid over each other with slight pressure.

With the development of the automobile the Johansson system

was accepted as being the best means of gauging and checking the various high precision tools, jigs and gauges necessary to the production of the automobile as we know it today.

Henry Ford, courageous, far-seeing genius of production and a master craftsman, by making Johansson a member of the Ford organisation, made it possible to produce these ingenious gauges under his personal supervision on a commercial scale, thus making them accessible to industry in all countries and of benefit to all mankind in raising standards of life.

One can now consider the production of parts to limits of $\frac{1}{10,000}$ of one inch. Within the last twenty years $\frac{1}{10,000}$ part of one inch has gradually become commonplace, without visualising what it means. To realise the progress that has been made one should understand the conditions under which pistons and cylinders were produced. Just over a century and a half ago James Watt was greatly hampered by the lack of machine tools, so the first cylinders were merely dressed and rubbed smooth with stones, by hand labour. When the first cylinder was bored, Watt rejoiced that it had been so well done that he could scarcely get half a crown piece between piston and cylinder. Greater progress was made when John Wilkinson at Bersham Iron Works in 1775 constructed the first self-acting boring bar, 12″ diameter, 15′ long. This bar bored all the cylinders for Watt between 1775 and 1795, the first known application of single point tool boring.

WHITWORTH AND WHITNEY

In measuring work and the production of interchangeable parts, great credit is due to Sir Joseph Whitworth, an eminent engineer of the early 19th century, and Eli Whitney, who was by profession a schoolmaster in America.

Whitworth's foundation was laid upon the understanding that a tool could not produce more accurate work than itself, but that a perfectly accurate tool was capable of making any approach to accuracy of production consistent with the skill of the man. The author believes there can be no departure from this principle and it is also the opinion of experienced observers in various parts of the world.

In a sequence of manufacturing operations, each operation should produce work as correct as possible ; subsequent operations should not be expected to correct inaccuracy made in earlier operations. Each operation should advance stage by stage towards precision in the finished article.

To Whitworth we are indebted, with those guiding principles in his mind, for the means of greater accuracy by the introduction of

measuring instruments to record fine limits. The production by him of the first cylindrical templets was a great achievement and as a means of an indication of size they cannot be surpassed.

It is possible to conceive the amount of labour and skill involved in arriving at the correct sizes of the first sets made. In the development of the gauges he produced his millionth measuring machine and this was presented to the Royal Society. It is a masterpiece of ingenuity.

To Whitworth we are also indebted for what has been standard practice in workshops for a century—the preparation of a standard surface plate and the method of employing it for the multiplication of other identical plane surfaces. This has been an outstanding invention in mechanics and with the development of the machine tool since Sir Joseph Whitworth's day its importance cannot be overestimated. When one realises that up to 1840 the practice was to obtain two working surfaces by rubbing them together with emery and oil—without skill and judgment it was impossible to obtain two flat surfaces. In originating the design of cast iron surface plates, the use of the hand scraping tool and the method of interchanging three plates, an advance was marked in the production of higher class machine tools at low cost, emphasising the close relation between good tools and gauging methods to produce goods of higher quality and lower cost of production.

ECONOMICAL PRODUCTION In the economical production of components the type of gauge must be considered. Tolerances are laid down, which must be maintained; any uncertainty in the means or method of gauging either adds to or decreases the tolerance. A percentage of parts will be rejected which are within the limits, or on the other hand, parts will be passed that are undersize or oversize and will not function as intended. The less perfect the surface the lower is the accuracy of the work being gauged. One cannot measure a rough turned shaft with the same degree of precision as one that is finely finished.

One may ask, why the need and demand for measuring instruments and machines for checking production work by means of instruments which are either kept in a glass case in some corner of the tool room or in the laboratory? This question can be readily answered if it is pointed out that the measuring or gauging means should be at least three times as accurate as the finished work. Such is the change in outlook which has taken place in recent years, that these instruments are now made for use in the commercial field, the general trend of development being to deviate from what one may term the orthodox or accepted methods of manufacture and measurement.

It would appear amazing to say today that practically nothing

had been done to provide facilities to space correctly two holes in the right place until after World War I—that is until just over 25 years ago, yet in the past 100 years many ingenious mechanical devices such as sewing machines, cameras, razor blades, typewriters, calculating machines, small arms and armaments have been made interchangeable.

The rapid growth of the motor car, electrical and plastic industries and the exacting demands for accuracy and interchangeability of the aero-engine manufacturers, demanded that such a need should be met. Tool rooms generally were considered as necessary evils and were usually left in the hands of skilled craftsmen, thousands of whom with inventive minds were not cost-minded or production conscious and therefore never pressed managements or principal for modernisation in their departments.

FIRST JIG BORER The first jig boring machines were built by the Société Genevoise of Geneva, Switzerland, and the famous firm of Pratt and Whitney of America, both firms having wide experience in the art of metrology, being able to measure in millionths of an inch and seconds of an arc. These machines with the Keller die sinking machines, have materially assisted in providing access to social amenities. We now have the wonderful De Vlieg machine, Moore jig borer and many others with built-in precision.

From Henry Maudsley's first lathe and Richard Robert's first planing machine developed the multi-station-multi-indexing vertical turning machines. Multi-tool automatic production lathes comprise all the basic principles of the early machines with the addition of refinements, made necessary and possible by the steady advancement in the development of cutting tools and the art of metal cutting. It was the great American, F. W. Taylor, who drew attention to the possibilities of increased productivity from this source.

If the managements who look at the first heavy initial cost of good tools and good tooling (and still remain ready to criticise the production departments for high costs of production and high costs of maintenance without giving close attention and examination to the factors which are responsible), would take the trouble to visit some of the well-equipped factories of their friends in the U.S.A. who are in a similar line of business to themselves, I feel sure they would come back and reflect not on whether they can afford it but whether they are able not to afford it, if we are going to live and face healthy competition.

RELATION BETWEEN INSPECTION AND PRODUCTION The Inspection Department, as part of the works organisation, is just as much concerned with the cost of production as any other section, but its job is concerned with maintaining standard of quality.

The inspector who carries out his job in the frame of mind that he has no interest in production costs and the foreman who thinks of inspection just as an unnecessary evil which has been thrust upon him and as an obstacle to be overcome, are equally out of place in any well-regulated factory organisation.

Production and inspection are sections of an organisation which exist for the purpose of producing work to the quantity required by the production programme and of the quality required by the customer or by the designers' own standard. Between inspection and production there should be a clear and mutual understanding, if that co-operation is to exist which will produce the results which the customers have a right to expect. There is, however, a tendency on the part of some production executives to press for production without worrying unduly about quality, so long as the articles they are producing will just get by the inspection department.

The factor of quality is often regarded by the zealous production executive as being of secondary importance and of being, in any case, the responsibility of inspection—the assumption apparently being that the existence of an inspection department absolves the production side from all responsibility for quality. This attitude is wrong and it has a retarding influence on production output, causing delays and dislocation on the production line and increasing costs of inspection and production. The decline of craftsmanship and pride in workmanship due to development of mass production methods and the increased use of semi-skilled labour coupled with payment by result systems, sets many problems in an inspection organisation, and it does not make the task any easier if the production line works too near the low limit of the standard required, sacrificing quality for quantity.

In these circumstances the inspection department, having no control over some of the factors which govern quality, can keep it up to the required standard only by rejection and demands for adjustment, an expensive method of achieving the objective and one which is wasteful and fundamentally wrong. To produce components to the standard of quality laid down by the designer on the drawing, the production departments should plan to produce work with good tooling and gauging methods not only to satisfy the programme in respect of quantity, but also with as much regard to quality as if there were no inspection to check up and take the responsibility in maintaining standards.

VALUE OF INSPECTION REPORTS

Inspection reports, if intelligently made out, i.e. stating the faults clearly and concisely using the standard terms for describing the operation, can be used to reduce costs on production because they point out where the rectifications and scrap are made. If a thorough investigation

is carried out into the cause and effect at the time the report is made out, considerable saving can be made on subsequent production, due in many cases to the operators not being clearly instructed and jigs and tools that are not efficiently designed or are in a poor state of repair. Production must be raised on a sound system of gauging to be successful.

In conclusion I would like to pay tribute to the enterprise, initiative and ability of many prominent members of our own Institution, who have exercised ingenuity by the improvement and development of gauging methods and providing means to assist production in obtaining a high level of precision and accuracy for British goods.

VARIOUS ASPECTS OF INSPECTION OF PRODUCTION

by F. NOURSE. *

Presented to the Western Section of the Institution, January 21st, 1948.

I am glad of this opportunity to talk to Production Engineers, and more particularly, perhaps, to those less senior members, about some aspects of engineering inspection, in order to emphasise the important contribution which inspection makes towards present-day production.

Every type of product requires to have a suitable form of inspection applied to it, although many of the fundamentals are the same. In the various branches of light engineering, inspection is of a similar character, varying mainly in the extent to which it is applied according to the particular nature of the product and the general standard of quality to be attained. Aircraft engine manufacture is fairly representative of the higher class of light engineering in view of the necessarily high degree of quality which has to be maintained, and the variety of technical processes involved, and it is to this type of work that reference will be made.

At various times I have heard the relationship of Inspection to Production described as a thorn in the side, a rose in the bosom, and a pain in the neck. No doubt inspection has been also referred to in other terms when parts which were thought to be nearly in the Finished Stores have failed to arrive there. But there is a good deal less of this sort of feeling nowadays on the part of modern Production Engineers, because they know that inspection today is an integral part of the complete production machine—all sections of which are interdependent in achieving the final product.

DEVELOPMENT OF INSPECTION It is interesting to look back and see in rough outline how this has come about, not only in regard to inspection but also to other branches of production.

I suppose the biggest changes have taken place in about the last 50 years and have become more rapid in recent times. In the old days, the quality of engineering work was mainly a matter of individual craftsmanship which had developed over a long period. The making of a product was usually initiated by one man, himself a craftsman. Sometimes it was a family affair. The quality of that product was a measure of one man's skill and of the ideals which he had set out to attain.

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If the demand for the product was greater than he alone could satisfy, he employed other men to help him. They worked with him to satisfy his standard of quality, and he saw for himself that it was attained. As the business grew and the number of workers increased, he did less active work himself but was still able to spend sufficient time in the works to see that the job was properly done, and was quite prepared to take off his coat if necessary. Some of these men were peppery old martinets, but they inspired respect because they knew their job and were generally good at heart.

At about this stage of growth and increased output, some of the responsibility of seeing that the work was properly carried out had to be delegated to others, and so we have the beginnings of inspection. This set-up is, of course, true of many small firms today and also of some quite large ones which have developed from a one-man beginning. The important point to observe is the principle that inspection exists for the purpose of assuring to the individual or group of people at the head of a concern, and to any Government department from which it has received inspection approval, that the quality of the product is that which is desired by them, whether it be a standard of quality which has grown up by tradition for the firm's own product, or whether it be a standard to which the firm has contracted to supply.

Inspection must, therefore, have a complete understanding of what is required and must merit the full confidence of the management in its ability to ensure that the product is maintained at the required standard.

The inspectional aspect assumed greater importance as manufacturing technique became more developed and as processes which had been previously been largely a matter of rule of thumb or were wrapped in a certain amount of mystery became better understood, and developed into more precise and orderly procedures carried out under proper technical control.

The importance of inspection as a unit of production further increased as production quantities became greater and as interchangeability of components became necessary. One of the earliest examples of this, if not the first, was in connection with the manufacture of Government small arms, where interchangeability of parts is of prime importance. This sort of interchangeable mass production we almost take for granted today, but I can remember the time when a replacement part for a motor-car either had to be made to measure or it was a major operation to fit it.

With the growth of precision mass production facilities, the production and inspection methods that were evolved became employed in smaller production plants and more generally throughout the engineering industry. The consequent higher quality and more efficient production was taken advantage of by firms with a

medium quantity production. Many such firms probably had an introduction to the advantages of improved inspection methods by the imposition of Government control during wartime. War conditions always cause a spurt of development in many directions and particularly so in engineering. Much new knowledge of methods and practices is thus brought to firms on war production who would not normally come into contact with it so readily, and this is often advantageously adapted to their peacetime production.

SCOPE OF MODERN INSPECTION

Modern inspection or, as I prefer to call it, quality control in the fullest sense of the word, covers a lot of ground. It begins with the raw material and follows it all through its various states of machining and the various treatment and technical processes to which it is subjected, through the assembly stages and its performance tests to the final despatch stage. It goes step by step with production all the way from beginning to end, and is also much concerned with what happens to the product after it has left the factory.

Inspection is the guardian of the ideals and the results for the attainment of which a production organisation exists. It ensures that the intentions of the designer are carried out and also imposes those further requirements which close contact with the production and functioning of the product has shown to be necessary. Inspection has often to be a sort of buffer between varying points of view, and sometimes an arbitrator between what is desirable and what is practicable. It must be in sympathetic relationship with production without ever losing sight of the ultimate goal. It must sometimes be a spur to production but must always be reasonable and sensible of its difficulties. It must be helpful to production and when things are not going well it is often able, from close contact with the job, to offer advice and suggestion.

The responsibilities of production and inspection must, however, always be properly shared. There is sometimes a tendency for production supervision to become too preoccupied with the business of output and to leave the inspection holding more than its proper share of responsibility. Such a state of affairs is bad for both production and inspection.

EFFECT OF SPECIALISATION

The complexity of engineering production has become much increased in recent years by the greater amount of technical and scientific knowledge which is being applied.

The mastery of a single aspect of it becomes a full-time job and there is in consequence a good deal of specialisation. One hears it said that the old form of craftsmanship is dying out, but it is probably more truthful to say that our native ingenuity and sense of craftsmanship is now being applied more to the *means* of pro-

duction rather than to the actual production itself. Production machinery has become developed to a degree that makes less demand on the skill of the operator, and in some cases has reached the stage of being almost a matter of pushing buttons. But much of this improved equipment is also available to the craftsman, and if some of his work has become deskilled as the result of push-button methods, I believe he is still the better craftsman for having some of the mechanical drudgery taken out of his work.

This development of modern production equipment, in which productive skill is being increasingly built into the machine, has an important bearing on the question of inspection. Not only is the inspection organisation more complex in character due to the necessarily wide coverage demanded by the variety and technical character of present-day methods and processes, but the manner of its application has to be adapted to suit the production methods being employed. At the one extreme is a small quantity free-hand made product in which each piece *could* be quite different from the next and would demand a comprehensive 100% inspection, and at the other extreme a fully mechanised product which would require only a running check to ensure that the production mechanism continues to function correctly. The more reliable the *method* of production as regards consistent reproduction with the least variation over large quantities, the better from the inspection point of view.

Where the production methods employed are showing themselves to be not quite meeting the case, with a resultant high proportion of rejections or rectifications, the inspection may have to press for a change. Similarly a change of method may have to be recommended if inspection finds that unsatisfactory functioning necessitates a raising of the standard of acceptance. Inspection should not be satisfied if a thing continues to be only just good enough, and it must press for an increased margin of goodness.

START OF INSPECTION

As already mentioned, inspection begins with the raw material. Whether it be in the form of forgings, sand or die castings, bars, tubes, sheets, etc., in ferrous, non-ferrous and non-metallic materials, suitable checks have to be applied to ensure that it is satisfactory for the purpose required. Broadly, the material has to be correct to specification and to be of a required standard of quality and dimensional accuracy. Much of the raw material for Government contracts may have already passed through a system of controls aimed at ensuring that it is up to the basic standard. This provides a considerable measure of assurance, but human nature being what it is, it is not safe to place complete reliance on it. If faulty or incorrect material should find its way into the factory it could cause considerable trouble, delay

and expense, and might even constitute a serious danger to the product. A suitable degree of incoming inspection is, therefore, justified as an insurance against such trouble.

Apart from the basic quality associated with certain supplies, there may be particular requirements that the material is ordered to fulfil which have to be specially checked. All sub-contracted parts—part machined or otherwise—also have to be suitably checked. The extent of the checks applied to incoming material is adjusted according to the importance of certain possible defects, and are graded according as experience indicates the reliability of the various sources of supply.

TYPES OF DEFECTS

Most of you will no doubt be painfully familiar with many of the various types of defects from which raw material can suffer. The common ones are, of course, roackes and seams in bars ; folds, laps, flash-line seams in forgings ; blowholes, cold shuts, draws, porosity and damage during fettling and so on in castings. There are, however, less obvious but important faults which like all forms of defect require the application of a suitable technique in order to detect them—faults like the burning and over-heating of steel, faulty grain structure in light alloys, the season cracking of bronzes and the decarburisation of spring material. The mixing of materials of incorrect specifications has also to be guarded against. Apart from many other complications it may be most troublesome, for example, to sort out, from a mass of similar parts, the components made from a rogue bar. Magnetic, electronic, chemical and physical checks mainly cover the general run of material defects. Conformity to specification is covered by tensile, impact, hardness and chemical checks, also by test pieces to prove correct response to heat treatment and for the predetermination of precise heat-treatment temperatures as necessitated by variations of material from batch to batch.

Forgings frequently have to be made to an approved technique and periodical macro-etched sections are taken to ensure that the required grain flow is being maintained.

Dimensional checks are fairly straightforward but need a good deal of watching in order to ensure that there are adequate but not excessive machining allowances, that there is no serious distortion, that spotting points are correctly maintained, and that the rough parts are suitable for accommodation in the jigs and fixtures. About the worst thing that forgings can do dimensionally is to grow due to the wear of dies, and periodically a halt has to be called if the forgers are inclined to run the dies too long.

Die castings are usually quite well behaved dimensionally, but sand castings—especially those of a complicated nature, can be full of surprises and booby traps. Without being unfair to foundry-

men, who have their full share of their own particular troubles, it is probably true to say that a dimensionally correct casting is comparatively rare. Wall thicknesses and mass sizes are generally above drawing, cores are not always just where they should be and core sand not completely removed. Occasionally chills may remain in places where they are out of sight.

In the development of the foundry technique for a new type of light alloy or other casting, destructive tests are the quickest and most informative, both for dimensional and material soundness, particularly in the early stages. Subsequently, X-rays can be usefully employed and are also helpful on routine tests for freedom from material defects, although pressure testing usually gives the final answer. Light alloy castings which do not withstand pressure test owing to fine porosity can be salvaged by impregnation in various ways, the most effective being the use of synthetic resin varnish applied under vacuum and temperature for sealing the porous areas.

Difficulties with the removal of core sand and the provision of proper facilities for internal examination sometimes mean calling in the designer to provide further means of access by means of additional core holes. The similar problem may also arise of the removal of machining swarf which has become trapped.

Surface faults and cracks in castings can be revealed by the old paraffin and chalk test, or by more modern variations of the method employing coloured dyes. The basic principle is the same, namely that of utilising the presence of oil in the crack to provide a surface indication by local retention of the surface chalk or by the formation of a dye line. Crack detector methods of a similar nature can be used, utilising the presence of crack oil carrying a fluorescent material such as anthracene and so making the line of the crack apparent under ultra-violet light, but such methods are not always convenient to apply.

Flaw and cavity defects deep inside billets or thick sections are revealed by supersonic methods, in which high frequency elastic vibrations are transmitted through the material from an exciting crystal at one point on the surface and are reflected by any material discontinuity to a similar receiving crystal at another point, the character of the received vibrations being shown electronically.

Among the tests for verification of material type are the nitric acid proving of stainless steel and the similar acid spot test, followed by a dimethyl glyoxime reaction for the proving of nickel bearing steels.

Electronic impedence bridge methods, employing the production of high frequency currents or magnetic fluxes in the material to indicate variations of resistance or permeability, are becoming increasingly used to show differences of composition and hardness

in the material. Where necessary, tests for elasticity and ductility are made, the latter being the Ericksen bulge test for sheet material.

Bar material generally is examined for correctness of material condition and freedom from external and internal defects. It is checked for size and for straightness suitable for use in collets. All bars and other materials are finally marked with the correct material colour coding before being passed to stores.

Checks are made of the quality of rubber components by hardness and elasticity tests and for their susceptibility to the effect of oils and other fluids. It is sometimes necessary for these tests to be repeated at intervals on parts which have been in storage for some time.

The inspection of parts during machining is dealt with in various ways according to the type of component, the method of machining and the rate of production. Whatever the form of subsequent inspection, the first of a batch is always examined for approval before proceeding with the remainder. Subsequent checks will then vary from 100% in the case of major operations, especially where datum faces are involved, to sampling checks varying in proportion according to the method of production and the extent to which it can be relied upon to produce uniformity of results.

QUALITY CONTROL

The so-called quality control method of sample viewing comes under this heading. When applied to parts produced from fully or semi-automatic equipment, periodic samples are dimensionally checked for conformity in a zone set within the permissible extremes of tolerance. Any marked tendency to drift outside the inner zone is corrected at the machine so as to ensure that all the parts produced are within the desired limits. In the case of fully automatic production of good equipment the probability of variation is small and the percentage of sampling can be low, being adjusted to the rate of production. For semi-automatic production and where the human element comes in to an increasing extent, the proportion of checks has to be increased according to the probability of variation—the aim always being to have the greatest assurance of correctness with the least amount of inspection.

High percentage of 100% operation viewing can be economically carried out on most operations, especially on long runs, if specialised inspection equipment is provided so that inspection time is low. Under such circumstances conveyor belts may be used for the components with the inspection stations at either the machine end or the stores end of the belt.

Full inspection is imperative at certain stages, notably prior to hardening operations or where the operation removes a datum face and creates a new one, or where for any reason it is not possible

beyond a certain stage to check back on previous operations. Composite checks on components or assemblies are made by receiver gauges usually at or near final inspection.

Heat treatment and hardening operations are checked by the usual hardness tests using various forms of ball or diamond indentors and loadings. The diamond hardness testing of internal surfaces, especially in small bores, sometimes calls for special adaptors as there is a curious shortage of suitably designed internal hardness testing equipment. The particular form of hardness test to be employed and the limits of acceptance are established for each component. The particular point on the component at which the impression is to be made is often of importance, and all hardness testing requirements are therefore best incorporated in a set of charts showing a diagram of each component, together with all the necessary data.

Carburised parts are checked for depth of casing either from test pieces or by etching the components themselves, if the design is suitable. All heat treatment pyrometry equipment should be under inspectional control as an assurance of correct conditions of treatment.

FAULTS IN MATERIALS

At suitable stages during machining, checks are required for the detection of material faults, either created by or revealed during machining. The faults concerned comprise grinding cracks and burns, material flaws and inclusions, mainly non-metallic, consisting of sulphides, silicates and oxides.

In magnetic materials surface cracks or flaws are shown by a line of black or red iron particles when the part is subjected to a magnetic field. The necessary field may be created in various ways according to the type of component and the direction in which the flaws are likely to lie, being always so arranged that the lines of magnetic force cut across the line of the crack. The component is placed between the poles of a D.C. magnet for transverse cracks or those running in random directions.

For the detection of longitudinal flaws a circumferential field is created by passing A.C. or D.C. current through the component, or through a conductor rod on which the components are threaded. According to the type of defect likely to be present, both types of magnetic fields may be applied successively.

In the case of large components or structures, the magnetic field may be produced locally in the region to be tested. The detector ink is always applied in the presence of the magnetic field. The use of residual magnetism is less effective and is less commonly employed. Strong magnetic fields will also reveal by surface indication the presence of defects which are appreciably below the surface.

A widely varying range of current strengths may be required for suitable magnetisation according to the nature of the component

and the type of defect being looked for. These should be established and recorded in order that consistency of test condition shall be maintained. It is important after all such tests that the parts be effectively demagnetised, for which purpose A.C. coils of suitable inside size are provided.

In non-magnetic materials the surface is examined by direct or binocular vision under suitable lighting after etching by nitric, sulphuric or hydrochloric acids, according to the type of material. The chalk or dye method previously mentioned may also be used for cracks. When inclusions are revealed, it may be necessary to take a sulphur print to discriminate between those due to sulphides and the much more harmful silicates. Standards of acceptance have to be set for particular components in regard to the permissible number and character of inclusions.

Grinding burns and surface softening are revealed by etching. If the burning is bad the etching will cause cracks, which were not previously apparent, to open up. On highly stressed components, grinding cracks and burns are to be most carefully avoided. Some surface treatments, like the anodising of aluminium and the chromating of magnesuim, very obligingly reveal surface flaws by local discolouration.

Magnetic tests may sometimes be applied to non-magnetic materials. In the case of spot or seam welds in stainless steel, for example, the soundness of the weld and the correct temperature of welding can be confirmed by applying a local permanent magnet field to one side of the component and observing the iron particle indications in a transparent ink container applied to the other side.

As in many similar cases where inspection has to rely largely on the correction application of method to ensure satisfactory results, the general technique of welding has to be established and the individual skill of welders approved before being applied to production.

Special problems often arise in inspection which necessitate the provision of suitable equipment. To be able to verify, for example, that a brazed joint is sound, or that the adhesion of white metal to steel is satisfactory, requires the use of an electric resistance bridge and a sensitive galvanometer. A similar device is used for measuring the thickness of wall sections which are not otherwise accessible for direct measurement. Magnetic types of instruments are also used for determining the thickness of plated or white metal coatings on ferrous bases.

USE OF WORKS LABORATORY

The works laboratory is also responsible for the technical control of all surface treatments and protective processes, such as plating of various kinds, bath strengths, anodising, chromating and the various phosphate treatments, such as coslettising, parkerising, granodising, etc.

On machined parts the classification of surface finish has been made possible during the last 15 years or so by the introduction of practical equipment for measuring degrees of surface roughness. Previously standards of finish were usually judged visually against a reference piece under oblique lighting by means of external or internal optical comparators, and such methods can still be usefully employed, although their application is somewhat limited and the conclusions are a matter of individual opinion.

Surface measuring machines such as are now available provide a definite numerical index of the degree of roughness and in their modern form are virtually precision measuring comparators. They are often used as such apart from their normal function. The test surface is traversed by a diamond point, whose vertical movements are communicated through calibrated electrical equipment to a meter which registers the average height of the roughness in micro-inches—that is, in millionths of an inch.

Alternatively, the electrical output can be connected to a pen recorder to produce a graph showing the precise form of the roughness. The meter reading and the graph can be used conjointly to judge a surface condition. Two different kinds of surface can produce the same meter reading and their graphs can then be used to determine which is the most desirable type. In this way it is possible to choose between two alternative methods of production.

The machine can also be used to measure and record any departure from true roundness of a cylindrical piece. In the case of grinding chatter, centreless grinding being the worst offender, the height and number of the lobes can be shown and measured. The machine will give roughness measurement on all kinds of surfaces whether external, internal, straight or curved.

The availability of surface measuring equipment may tend to focus too much attention on the subject and to cause a striving for unnecessarily high finishes. The cases in which a particular finish on a component is necessary for its proper functioning are actually comparatively few, but they are important and have to be determined by experience. These may not always be high finishes. Certain degrees of roughness may sometimes be desirable, but whatever the desired finish may be, it can be established and measured. When the best and most reliable method of obtaining the desired finish is established, only periodic checks are necessary.

In the case of the higher finishes, honing is quite the best method of assuring a uniformally high standard of finish, and with suitable types of hones also improves the geometry of roundness, parallelity or flatness of the surface. With certain desired final finishes it may be necessary to control the approach finishes of previous grinding or tooling operations. Once a certain necessary type of finish is established, the figure can be put on the component drawing or

process sheet, and is expressed as a maximum figure in micro-inches. In those cases where a controlled roughness is required, the maximum and minimum micro-inch figures are quoted.

The other less critical but still important surfaces are also the subject of periodical and recorded checks, to ensure that they keep within the range customary for the production concerned.

DRAWING REQUIREMENTS

The mention of component drawings raises the subject of the amount of information provided thereon for production and inspection. This usually covers the main requirements of the component, its general shape, dimensions and tolerances and so on, but there are often a number of features not usually referred to and which are assumed by the designer to have the required degree of accuracy. Features such as straightness, parallelity, flatness, concentricity, lineability of a bore with the outside diameter, the centralisation of slots or tongues, the squareness of faces and threads with the axis, angles, dividing and spacing, curvature and radii—many of these are seldom given tolerances, and shop standards have to be set. I have heard it claimed, as I expect some of you have, that the tolerance on a diameter can be applied also as the tolerance on roundness and parallelity !

But many of these features are of importance to the proper assembly and functioning of the component. A drawing note such as " truly radial " or " dead square " sometimes appears, which at least serves to call attention to the need for special care, but in the absence of any specific limits on most of these matters of geometry, the necessary standards have to be set by inspection.

These standards are established from experience, and may be adjusted from time to time as further experience is gained. It is again very often a compromise between what is desirable and what is attainable with existing methods until improved facilities are available.

With regard to the dimensional control of machined parts, this can be dealt with in a variety of ways depending mainly on the type of part, the quantity to be inspected, the limits involved and the length of time they are going to be in production. Simple parts in relatively small quantities can be dealt with by standard measuring tools, with which you are mostly familiar—the micrometer, vernier, depth gauge, plain and screwed plugs and rings, etc. together possibly with a few special gauges to suit the component.

As the quantities become greater and become time extended, the cost of the provision of a greater proportion of single purpose gauges becomes justified. The grouping of simple measuring units on fixtures, whereby the part is taken to the gauge instead of vice versa, is convenient and reduces handling time. In certain cases the

provision of special gauging equipment may be necessary at the outset in order to ensure control of some critical feature. It is important that all such inspection equipment be designed and provisioned at the time the work is processed. As production quantities become still greater the provision of an increased amount of specialised equipment is justified in order to maintain efficiency and keep down inspection costs.

At this stage single-purpose multiple gauges may be used, which at one movement check a number of dimensional or other features simultaneously for conformity within pre-set limits.

It is not a very great stretch of imagination to visualise a production of such a character and magnitude as to justify the provision of fully-automatic inspection machines, through which the components pass at intervals and with the human element reduced to a few control, recording and maintenance units. Going still further, such automatic inspection equipment could be built into the production machines themselves, and be so arranged as to make automatic and immediate correction to the settings as required. It could be made to signal if it was beginning to get into trouble and automatically to shut down when the machine was beyond further automatic control in any respect.

The development of electronic equipment during recent years makes the provision of such devices technically possible. In fact, there are already existing dynamic balancing machines with interconnected drilling machines which are electronically self adjusting for the removal of the required amount of weight from the component concerned.

MEASURING EQUIPMENT Returning to the subject of measuring equipment, this always involves, once we depart from the foot-rule stage —some form of magnification in order to provide a useful or visible indication of small differences of dimension. These methods of magnification may be mechanical and optical, either separately or in combination, electrical or pneumatic.

Of the mechanical type the screw thread of the familiar micrometer makes a thousandth look like a sixteenth and sometimes has a vernier wrapped round the barrel for good measure. Occasionally the basic micrometer takes quite elaborate form with a precision screw thread, a quite large vernier barrel and incorporates some form of constant contact-pressure device.

There is the rack and pinion clockwork of the dial indicator and many forms of lever systems operating either quadrants or dial indicator comparators. A good deal of ingenuity and some very nice workmanship is put into these instruments. Combined mechanical and optical instruments include the moving mirror and light beam lever type used for the high-magnification checking of

reference standards. Optical methods include the calibrated microscope and the magnification by direct component projection against a screen incorporating a master form or scales. For very small components of critical form this method is about the only practical one for inspection.

Optical projection has its limitations as regards size of component field and magnification, the limit without distortion being set by the size and cost of the lenses. For example, a field of about $1\frac{3}{8}''$ diameter can go up to 10 magnifications, whereas a $\frac{1}{8}''$ field can go up to 100. Among optical inspection equipment is the introscope, provided in suitable size and form for inspection down long holes or in other awkward places not accessible by direct vision.

There are several forms of pneumatic gauges all based on the effect of varying air flow from orifices caused by differences of clearance between the jet and the component and registering on calibrated fluid columns or dial gauges. They have the advantage of having no measuring point contact with the work, and are especially convenient when it is desirable not to have any appreciable measuring pressure on a slender component. They have also the advantage of being able to take quickly a number of readings on a component of large surface area. Electric gauges, which operate from the contact point through inductance or capacity systems and amplifiers on to calibrated meters, are capable of high magnification and can also be readily varied in ratio.

With the air and electric instruments, especially when being worked at high sensitivity, the setting and calibration has to be periodically checked.

All the comparator type instruments referred to have a limited scale reading and have to be set to a basic size from which to operate. This setting can be made either from special setting pieces provided, or from standard measuring blocks made up to the required dimension. These are known from the name of their originator as Johansson gauges, but are now made in most countries by a few high grade tool making firms under the approval of their respective Government metrological departments.

WHAT IS AN INCH? This seems a good point at which to consider how the unit of length is established—or in other words, what is an inch? It is a subdivision of the Imperial Standard Yard, which, together with the International Prototype Metre, is the fundamental unit of length established by law. These are metal bars and some of the earliest yardsticks are now museum pieces. There are two belonging to the Henry VII and Elizabeth periods in the South Kensington Museum. A later one was destroyed when the Houses of Parliament were burned down in 1834.

The length of the original standard yard was apparently related

to the length of a pendulum swinging seconds in vacuum at sea level on the latitude of London. The present Imperial Standard and four of its copies were cast in 1845 and were legalised by Act of Parliament in 1855. A fifth copy was cast in 1878. The Standard itself and one of the copies are held by the Board of Trade Standards Department, and one copy each by the Royal Mint, the Royal Society and the Royal Observatory. The remaining one is walled up in the Palace of Westminster.

With the exception of this latter copy, the Standard and its copies are intercompared about every 10 years by the National Physical Laboratory. One of these comparisons was due in 1942, but had to be deferred owing to the war, and is now in progress. Comparison is also made with the Board of Trade derived standards and with the working standards of the N.P.L.

As a matter of interest, these Yard standards are bronze bars of 1″ square section, 38″ long with a recess ½″ diameter and ½″ deep at one inch from each end. In the bottom of each of these recesses is a small polished gold plug having engraved lines which provide the points of optical measurement.

The Prototype Metre is held by the International Metric Bureau in France. The length of the metre was originally defined as being a ten-millionth part of the earth's polar quadrant. There are a number of copies of the metre, the British National copy being in the custody of the N.P.L. The Metre Standard Bars are 90% platinum, 10% indium and are roughly x-shaped in section with engraved measuring lines near each end. As in the case of the yard, the copies are periodically compared with the prototype. The use of the Metric System in Great Britain was sanctioned in 1864 and legalised in 1897.

Copies of the British yard were supplied to America in 1856 and, as in this country, both the yard and the metre are accepted standards of measurement. But the position in America is interesting because since 1893 the metre and not the yard has, by order of the United States Treasury, been regarded as the fundamental Standard. The yard, therefore, becomes secondary to the metre and since the metre has been determined as 39.37″ precisely, instead of the accepted figure of 39.370147″, the American inch is consequently longer than the British inch—actually about four millionths.

The maintenance of length standards by means of metal bars has certain physical disadvantages, and it seems probable that at some future time they will be discontinued in favour of expressing the standards in terms of the wavelength of monochromatic light. This would provide greater accuracy and greater convenience internationally in reproducing the standards instead of having to base them on pendulums and bits of polar quadrant.

Sub-divisions of the national measure in the form of approved steel blocks or bars are the basis of workshop dimensional control. Up to about 4 inches, gauge blocks are usually employed, but for lengths greater than this the bar or rod gauge is more convenient to make and use.

THE STANDARDS ROOM

In factories where a good deal of precision measuring equipment is used which has to be periodically checked or adjusted, the high grade reference standards which it is necessary to maintain are usually centralised in a Standards Room, where precision measuring can be carried out as nearly as possible in conformity with the National Standard. For this purpose the Standards Room is air-conditioned and the temperature maintained at 68° F. In addition to operating with reference standards it may also be provided with measuring machines, having N.P.L. calibrated linear scales read by microscopes and incorporating precision micrometer heads and other attachments.

Such measuring machines may have a capacity up to 40″ in length or be capable of operating to scale and micrometer readings in three planes. Together with a range of accessories, such machines are capable of carrying out the precision examination of complex gauge equipment and also of the dimensional investigation of components by direct measurement.

Standards Room equipment will usually embody various comparators including the high sensitivity mirror type for checking of production and inspection working gauge blocks against the reference standards; machines for the internal measurement of plain or screw rings; for the checking of the effective diameter and pitch of screwed plugs, for the measuring of angles either by dividing heads or sine bar equipment; optical projection equipment for the checking of gauge profiles, tool forms or components against enlarged master form templets, either by direct projection or by means of graphite and sulphur casts.

The Standards Room may also contain other items of equipment specially designed or adapted for the precision measurement of gauges or components peculiar to the type of product, and pantograph devices producing scratch records on smoked glass for use in connection with the checking or investigation of toothed components or other angularly divided forms.

The service section of the Standards Room periodically checks all working gauges and resets, if necessary, the adjustable types such as plain calipers and solid or roller anvil thread gauges. Records are kept of the checking of all major gauges, the frequency of check being determined by experience of the degree of wear or damage likely to be sustained each according to their particular duty and

the amount of work being gauged. In general, it may vary from a few weeks to a few months, but apart from routine checking gauges may be sent to the Standards Room at any time at the inspector's discretion. Some small screw gauges may last only a few days.

HANDLING TRANSPORT AND STORAGE

Returning to the shops again, a production matter which is of particular concern to inspection—especially in the machine shops—is the manner in which components and units are handled, transported and stored to keep them properly protected from damage and corrosion.

It is an important feature of the layout to see that the necessary provision is made all along the line to ensure freedom from damage, and very often too little attention is given to this important matter. After time, money and effort have been put into the product, it is all too easy for it to be marred later on due to lack of proper care and protection. Extra inspection is involved and if parts are not actually rendered unusable, they often require extra work to make them serviceable. In any case they have inevitably lost some of their quality, and inspection has the unenviable job of deciding how their usability balances against their substandard quality.

The use of proper containers, separators or racks will guard against much of the bruising type of damage. Such things must, however, be of a type that will not collect foreign matter, which itself will cause scoring or scratching. General cleanliness is of importance, not merely shop cleanliness but of all faces, fixtures or surfaces on which components at any time rest, especially the heavier ones which otherwise may get badly scored. Small pieces are not usually heavy enough to do each other much harm, but when weight becomes appreciable and especially if the parts have sharp corners or edges, they must be protected. Even slight bruising may affect assembly or functioning or even cause serious weakening on a stressed component.

Often the cleaning of components and the need for removal of rags, burrs and frays on components submitted for inspection take up the inspector's time in guarding against the risk of damage.

The salvaging and reclamation of components which are incorrectly machined or have in some way sustained accidental damage during machining have to be dealt with by an organised section of the inspection department. At the normal stage of inspection, such parts are first registered as scrap and the decision is then taken as to whether they are worth salvaging. If this is thought probable they are passed to the salvage department for further consideration. Here they may be thrown out or considered suitable for treatment, in which case they are dealt with in accordance with prescribed salvaging methods established in agreement

with the design department. Any necessary supplementary machining and fitting work is carried out under the supervision of the salvage department, and when satisfactory the part is restored to its place in the production line. In the case of major salvages, the component is suitably marked and records kept.

The salvaging of components by the removal of broken drills and taps is also dealt with by the salvage department. These may be dissolved away by suitable acids, but the more effective and quicker method is by mechanised electric burning.

FAILURES IN SERVICE

The investigation of service failures is an important branch of inspection. From such investigations much can be learned to supplement existing experience which can be applied to the inspection of new production.

Often such failures are the result of overload or abnormal conditions, but they may also indicate some direction in which design material or manufacturing improvement can be made. The results of such investigations have to be very carefully considered in order that proper conclusions may be reached. From such investigations and in other ways, useful information and advice can be provided for the service department.

Speaking of investigations, the need often arises for enquiry into irregularities which occur in the course of normal production. This is best dealt with by a section of the organisation which is quite independent of the routine inspection, consisting of a group of quality observers and checkers selected from experienced inspectors. These are appointed to cover allotted sections with free-lance authority, to make random checks on inspection efficiency, to observe productive practices, to note any unsatisfactory procedures, to note any weaknesses in either production or inspection methods and equipment such as are likely to cause or fail to reveal unsuspected faults, to carry out investigation in the case of any trouble, and generally to be of assistance to the inspection and production supervision. It may be that everything has been produced according to plan and has passed the prescribed tests but is still not behaving satisfactorily. This condition may arise for no apparent reason, after having been satisfactory for a long period. The cause of the trouble has to be located and a satisfactory cure proved out and applied. In such cases little sympathy is received or expected from the design department, and usually the need for overcoming the trouble is an urgent production matter. As inspection is responsible for setting the standards of acceptance, it is morally obliged to provide the answer and to readjust the requirements in order to put things right again.

In such investigations all the resources of the inspection organisation and the laboratory are available in carrying them out. The

trouble may be metallurgical and a new technique may be necessary. It may be due to a drifting of fits and clearances into undesirable tightness or slackness. It may be one of those unsuspected faults already mentioned arising from an undesirable practice, or may arise from an innocent looking and well meant change of method. It may be the cumulative effect of increasing duty on the component. The cure may be simple or it may mean a change of production method, or in the last resort require some attention from design.

Routine inspection, however capable, is not infallible and may tend to get either slack or too closely focussed. The quality observer with a freer outlook can see a little more of the wood through the trees and can also note many of those odd things which can affect quality, but which normally it is nobody's particular business to attend to. Usually the time when things are apparently going well is a good time to look for something going wrong. The earlier that signs of trouble or a diminishing margin of safety are observed, the better for all concerned. A good inspectional organisation makes all the provision it reasonably can to ensure that things go right, but is always wondering whether it is doing quite enough.

INSPECTION OF ASSEMBLY

The assembly of production usually requires a higher proportion of inspectional attention than the machining side, owing to there being more of the human element involved and due to the importance of ensuring that the product in its later stages is fulfilling all its functioning and conditional requirements.

In a complex product comprising a number of units, each unit stage has to be checked and if necessary functionally tested, examined and reassembled. The unit test schedules are established by inspection laying down the conditions of test and the functioning requirements of development tests. The testing of the completed product is also carried out to similar schedules and inspectionally observed. In the course of the assembly of this type of product, a great variety of checks have to be made or observed at various stages including, among many others, static and dynamic balancing, pressure tests and oil flow tests, the checking of important assembly fits, clearances, and floats and backlashes, the correct application of torque loadings and the fitting of locking devices, the correct methods of assembly and the use of assembly tools, the proper use of jointing compounds and anti-fretting coatings, any necessary blanking to exclude foreign bodies, completeness to schedule and to modification standard, the examination after preliminary test, the correction of any defects, and prescribing the required form of retest or final test and the degree of reinspection necessary; and finally, the examination of the completed product prior to despatch clearance.

This involves the keeping of a number of detail records at various stages, which finally all come together to form a composite record of the manufacture of the product and from which any official despatch documents are prepared.

The translation of the designer's creation from paper-work into the final physical thing which he visualised calls upon a long sequence of technical functions. It is the duty of inspection to have a full understanding of what the designer's intentions are, and to co-ordinate all the various stages in order to ensure the ultimate result.

EXPERIMENTAL WORK

This is especially true in the case of new designs during the experimental and development stage. The inspection of experimental work has to be extremely critical, and particularly alert in observations of things not working out as intended.

Much time and money can be saved by realising at an early stage that either the method of manufacture or the quality of the design is not quite meeting the practical requirements with sufficient margin of safety. Much shrewd foresight is often required in order to prevent something being cleared to production as satisfactory, when it is lacking in the proper margin of satisfaction as regards producibility or functioning—something which might be very costly to remedy later on.

Very complete and accurate recording is necessary during inspection on experimental work in order to provide the designer and the development engineer with the fullest information for their guidance at every stage, attention if necessary being called to apparently insignificant points and with special emphasis on the more important features which require their attention. Powerful persuasion is sometimes necessary to overcome the designer's natural reluctance to make major changes which practical results and judgment have indicated to be necessary.

Dimensional inspection on such new work is inclined to be laborious by first principle methods and standard equipment, as at this stage much special equipment, which will come into being later on, is not yet available. Some special equipment may be necessary at quite an early stage and much ingenious improvisation will be called for which, when the work goes into production, will provide the basis for a developed design of equipment or a particular inspection method.

Very close contact is necessary between the machine shops or other productive sources and the inspection on experimental work, especially when new production methods are involved or when the design has new characteristics with which fresh experience has to be gained. On all new work the careful recording of results and

experiences is important also in regard to the handing on of such information as will be of value to the production inspection, who will at a later stage have to handle the job. All those things which have been learned during the development stage and which form the "know-how" of the job are important for their guidance.

It is too much to hope that the subsequent wider experience on later production will never reveal any further difficulties to be overcome, but by taking the fullest advantage of experience already gained, many troubles can be avoided. This written experience becomes amplified as further and more detailed production experience is obtained, until finally a comprehensive write-up is created, which contains in the fullest detail in the form of Fitting and Inspection Instructions, all the information required by both production and inspection concerning the technical details of manufacturing and assembly procedure.

It will thus be seen that with a high quality engineering product there is hardly any phase of production which is without its corresponding aspect of inspection. Inspection should be the severest critic of production in order that between them they may create something of which both can be justly proud.

In closing I wish to acknowledge the kindness of the Bristol Aeroplane Company for permitting reference to be made in some detail to the inspection organisation of the Aero-Engine Division.

DISCUSSION

Mr. G. Wright : The lecturer has very efficiently provided quite a few of us with the answer to the age-old question, "What do these inspection people do ?." Furthermore, I was very pleased to hear him bring out two points which I think can well be noted. Firstly, the design and detail draughtsmen will note that the component drawing should be as comprehensive as possible and secondly, the jig and tool draughtsmen and tool engineers will ponder on the remarks to the effect that inspection equipment should be provided at the same time as the equipment to do the job. Mr. Nourse has covered the subject very comprehensively and I now have pleasure in declaring the meeting open to discussion.

Mr. Balchin : I would like to ask Mr. Nourse if he could tell us his idea of the ratio of the number of inspectors required to cover a general machine shop working with millers, grinders, etc.

Mr. Nourse : Much depends on how the ratio is arrived at. On one side is the number of inspectors, on the other side you may count only the productive people who are actually at work on components. The type of shop and work produced must also be taken into account, but I should think, in a general way, for a high-class product the ratio of five or six productives to one inspector would not be very far out.

Mr. Reid : Referring to the speaker's reply concerning the number of inspectors, the figure of five or six to one inspector is roughly 20 per cent. I should gather that there will be 100 per cent. inspection on details produced in that shop.

Mr. Nourse : Yes, on some proportion of the parts produced—so much depends on the product. I gave those figures as representative of the ratio in the average case of the high-class product where a fair mixture or percentage of inspection is carried out. The number of inspectors, of course, depends on the amount of inspection which has to be done.

Mr. Reid : I would like to ask Mr. Nourse if he can give me some indication as to when the question of gauges is considered and who provides them. Is the planner responsible for provisioning ?

Mr. Nourse : In the main—yes. Much of the equipment is a repeat of that which is necessary for production. Those gauges which have no production equivalent should be determined in consultation with the inspection supervision of the shop which is to do the work. When the question of inspection gauges comes under the classification of specialised inspection equipment, such as multiple, special purpose or receiver gauges, it is a matter for the inspection organisation to deal with. As it is also a matter which concerns the cost of inspection, the Inspection Department would decide what type of equipment is most suitable or economically justified and its views would be passed on to the equipment engineer. Specialised equipment such as single purpose multiple electrical gauges of the type provided by an American gauge company would have drawing tolerances or inspectional tolerances built into them. As mentioned in the paper, this type of specialised equipment is costly and would only be justified if the output was sufficiently high.

Mr. Hugill : Mr. Nourse mentioned cases where a minimum as well as a maximum degree of roughness was specified. I am trying to visualise a circumstance where that condition would apply but being unable to do so, I would be glad if Mr. Nourse would quote an example and a reason for quoting a minimum degree. I cannot quite understand the principle upon which he applied magnetic crack detection technique on non-magnetic materials.

Mr. Nourse : These instances of minimum roughness are rather rare, but they do occur. It may arise for example in the case of a component required to produce for itself a particular form of surface during running by self-surfacing. Some materials under a particular kind of duty produce for themselves a desirable type of running surface when provided with a suitable type of initial finish to enable them to do so. In such cases, a certain degree and character of

original roughness is necessary to enable this self-surfacing to take place, and the degree of roughness required lies within a range determined by experience—usually under 50 micro-inches.

[*Author's Note :* The ultimate self-produced surface may have a comparatively low micro-inch finish, but it has other qualities which cannot be produced in the machine shop.

In the case of a nitrided austenitic steel cylinder bore, the required roughness range is between 20 and 40 micro-inches produced by lapping. Much the same is true of a chromium plated cylinder bore, in which case the required roughness may be produced by the method of plating. In other instances, the roughness may be produced by grit blasting the surface. This self-surfacing phenomenon appears to be mainly related to certain types of sliding surfaces. Generally speaking, in the case of rotary surfaces the highest degree of surface finish and geometrical accuracy is desirable.]

As for the second part of the question, I refer to the magnetic testing of welded stainless steel, and it is an interesting application. It is one of those things that should not happen, but it does. The application of a strong local magnetic field to the welded area will produce no effect on the iron particles in the detector fluid if the weld is sound, and the welding temperature has been properly controlled. If the reverse is the case, a condition of material instability exists in the region of the defective weld, which is capable of disturbing the magnetic field and of producing a corresponding indication in the detector fluid.

Mr. R. S. Brown : During Mr. Nourse's talk, he mentioned the question of quality being set by inspection from the inception, and thinking in terms of the small engineering shop with a general type of machine, would he say that standard or quality of inspection specified for the subsequent product should be based on a prototype assembly made up to the department's requirements, and that the standard is set on this basis or simply fixed on the shop capability?

Mr. Nourse : I think I would say that the standard must be based on what experience you have of the product ; it depends on whether it is a different product from what is normally produced. A firm dealing with a variety of articles of similar character will gather a great amount of experience.

Mr. R. S. Brown : I meant the sub-contractor type, the small general firm which takes over a job for someone else and which has been designed by someone else.

Mr. Nourse : They just have to do the best with what experience they may have. They would be provided with a model unit with which the designer is satisfied, and they would be expected to produce a similar part.

Mr. Ritchings : I would refer to the point about drawings being comprehensive. Whenever I have approached designers I have always found them extremely reticent and invariably have been

referred to the Inspection Department. Much time is wasted by chasing the Drawing Office to find out these things. Has Mr. Nourse come across a company where these points are cleared up ?

Mr. Nourse : I have been at various times a designer, a producer and now an inspector, and I can appreciate the various points of view. I will answer the last part first, as to whether anybody does provide full information. I have never seen a really classic example of completeness on drawings. America is leading us in that respect, and I have seen fairly recently some examples of American component drawings which perhaps do not tell the whole story, but they do give a good deal of production information and include references and limits to some of the geometric features.

With regard to the first part of the question—why drawings are not more comprehensive—I think there are several answers. It may be just inability, or it may be a lack of confidence in being able to assess manufacturing requirements to which the shops can work. The designer is always reluctant to put anything on the drawing which may have to be altered later on. Some manufacturing requirements are liable to change according to production methods or experience of functioning. Altering drawings is something to be avoided as far as possible, especially where there is a big circulation. Therefore, rather than risk putting too much on the drawing there is a tendency to put too little and to rely on inspection to look after the rest. Even so, there are often requirements which the nature of the design demands, such as concentricity, alignment squareness and so forth, which should be pointed out on the drawing, and which might at least be given tentative maximum limits.

[*Author's Note :* Where, as is usually the case, only the bare bones of the component are given, it is often necessary to study the assembly drawings (always supposing that they are available for a new design) to see where the manufacturing and assembly snags are likely to be, and to make provision accordingly. Even so, some subtle point may be missed. A bit more study from this angle on the part of the designer or detail draughtsman might well produce some simplification of design as well as making the drawing more informative.

More collaboration between the designer and the producers, particularly in the early stages of a new design, might well be helpful to both parties and to the product, without involving any loss of prestige or authority to the designer. I believe there is a good deal more of this sort of thing done in America than is usually the case in this country. The completeness of drawings as regards production requirements is particularly important when they are being sent out to sub-contractors.]

Mr. Folland : Mr. Nourse has given us an interesting lecture on inspection requirements, aids and equipment, but I feel there is one important aspect which has not been touched upon and that is the actual method of carrying out inspection of a job by inspectors, whether they check details A or B first. There is no method or sequence of checking laid down for inspectors to tackle a job. There

is nothing similar, on inspection, to the process engineer. Could we have information regarding the best means of tackling inspection generally?

Mr. Nourse : I think it will be very difficult to comment usefully on this question of inspection processing unless you indicate precise cases. Where specialised equipment is provided, the equipment would largely control the manner in which the job is done. Also, the type of men dealing with the job and their experience of that particular component would generally indicate the manner in which it should be tackled.

Mr. Rainey : Mr. Nourse referred to the inspection having a knowledge of what the designer had in mind. Does he suggest that that knowledge should be available to, say, the machine shop inspector? If so, how does he suggest it should be conveyed to him, and to what purpose should it be put ? Should it be made available to the individual or should it be limited to the supervision ?

Mr. Nourse : The shop inspector handling a certain type of part should have sufficient knowledge of the functional requirements of the part to enable him to say whether it would be satisfactory or not. Basically, he works to the drawing requirements so far as they are given and also, within a limited discretion, to those further requirements which experience and instruction have shown to be necessary. Beyond this point any questions of doubt are referred to the inspection supervision.

Mr. Pardy : We know that processes are laid out in regard to production. Surely it is possible to lay out a similar process for inspection and get a proper routine so that as the part goes through the shop the inspection process can be followed and the inspector knows just how he has got to work.

Mr. Nourse : Any inspector, given the responsibility of handling a particular job, should know how to tackle it. Usually operations are very much sub-divided, and it does not matter perhaps very much which way they are done if one particular face is correct from which others are dimensioned. In a complex component where the order of inspection is important, it is often wrapped up with the machining process. There may be cases of components where the sequence of operations has to be laid out not so much in the way in which production would best like to tackle them, but in the order in which inspection should take place. In these cases the layout of the process would control the sequence of operation.

Mr. Pardy : Mr. Nourse has touched very ably upon the matter of equipment and accuracy for the right production of the article concerned, but in his experience has he found that the effect of speed of removal of material results in subsequent inaccuracy of work ?

Mr. Nourse : I presume that you refer to the heat generated by the brutal cutting of material if part goes through the operation very quickly. With some materials it is often necessary to guard against too rapid removal of material, as this can have an adverse effect on the mechanical properties. It is, of course, a matter of some importance to ensure that at the stage when it is dimensionally checked, the part is reasonably at shop temperature. The heavy removal of metal at the roughing stage can, of course, set up thermal stresses which should be removed by suitable low-temperature heat treatment before any close-limited finishing operations are carried out, and to prevent any subsequent distortion.

Notes

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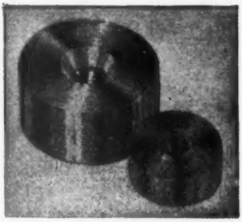

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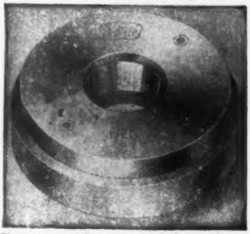

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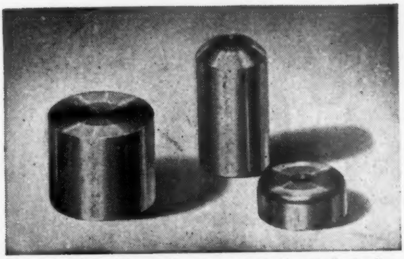

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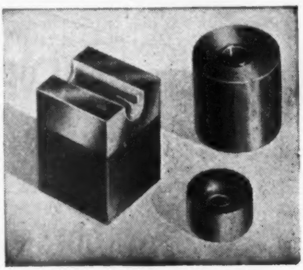

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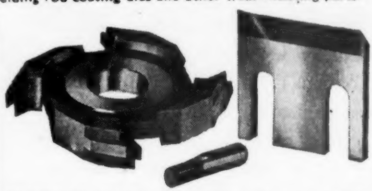

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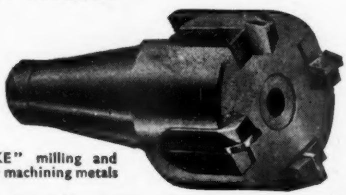

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IGNORING THE FACT that in these days you may well *have* no shirt to put on my little horses, I yet make the suggestion. You may think that we only supply drills, screwdrivers and nut-runners. Then you have another think coming.

If your production involves any operation that must be done by hand or with a handtool, it is likely that my little horses will enable you to produce more goods in less time. We make tools to unscrew the moulds in plastic products; to cut sheet metal, to drive woodscrews. In fact whatever your enterprise . . . (No! I shouldn't have said that) . . . whatever your problem (we do still have problems, don't we?) my little horses will come galloping to your aid.

STAND 284, FIRST FLOOR
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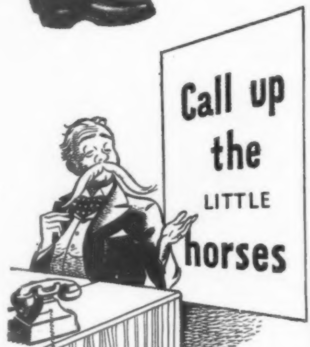

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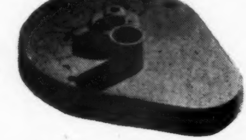

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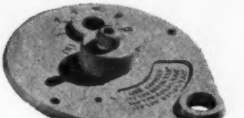
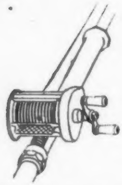


greater than

the whole



THESE ZINC alloy die castings are the fisherman's friend and the fish's enemy. For they form the cover of the Elarex Fishing Reel.*

Why the parts are zinc alloy die cast

The castings fit with the precision of a watch case, protecting the mechanism from dirt or water and so ensuring its smooth running. Lettering and figures are incorporated in the casting. The zinc alloy provides the strength, and the castings are made light by the use of ribs.

Other sports equipment too

Zinc alloy die casting is also used for golf club heads, cartridge holders, shooting stick tops, ski boot footings and binocular frames.

Some facts about zinc alloy die casting

Speed of production is an outstanding feature of the die casting process — the shortest distance between raw material and finished product. Zinc alloys are the most widely used of all metals for diecasting because they yield castings with the following qualities:

STRENGTH: Good mechanical properties for stressed components.
ACCURACY: Castings can be made practically to finished dimensions and need little or no machining.
STABILITY: Close tolerances are maintained throughout the life of the casting.

These are the properties which accounted for the widespread wartime use of zinc alloy die casting in the quantity production of such things as fuses, gun sights, periscopes and tank carburettors.

British Standard 1004

Alloys conforming to B.S. 1004 should be specified for all applications where strength, accuracy and stability are essential.

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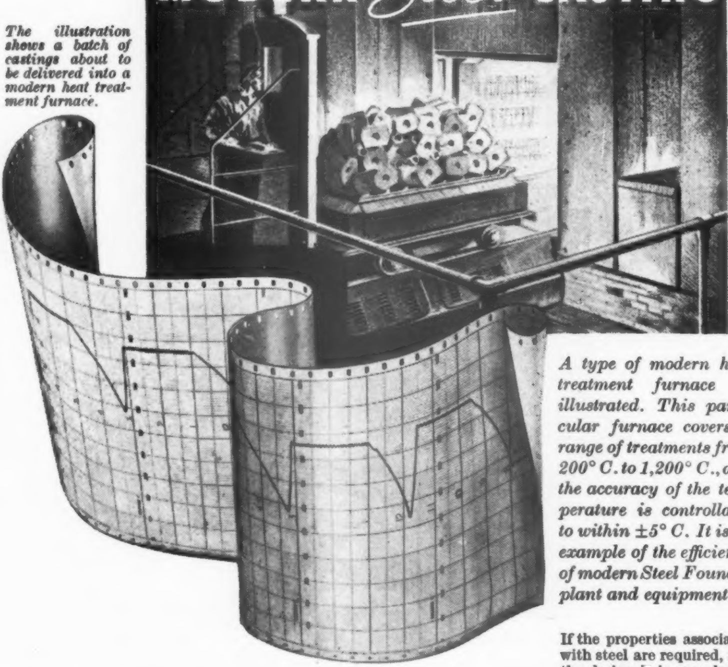
THE *Attributes* OF THE MODERN *Steel* CASTING

The illustration shows a batch of castings about to be delivered into a modern heat treatment furnace.



A type of modern heat treatment furnace is illustrated. This particular furnace covers a range of treatments from 200° C. to 1,200° C., and the accuracy of the temperature is controllable to within ±5° C. It is an example of the efficiency of modern Steel Foundry plant and equipment.

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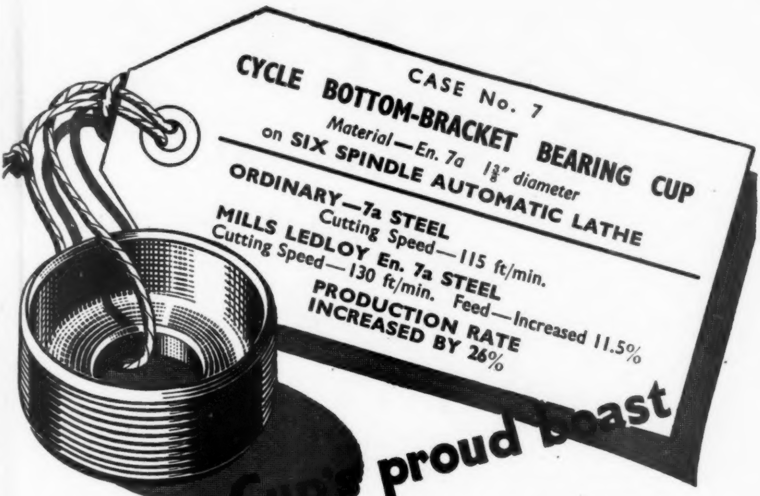

Bearing Cup's proud boast

Above is a portrait of a Cycle Bottom-bracket Bearing Cup, with its diploma tied round its neck. Cut from Mills Ledloy steel, it boasts a production increase of 26% over its rival, cut from ordinary steel under parallel conditions. Twenty-six per cent. . . . that's a lot . . . but the Mills Ledloy case-books record other examples where the gain is even more dramatic, sometimes as much as a hundred per cent. And, in every case, Mills Ledloy steel is far kinder to machine tools than other steels are.

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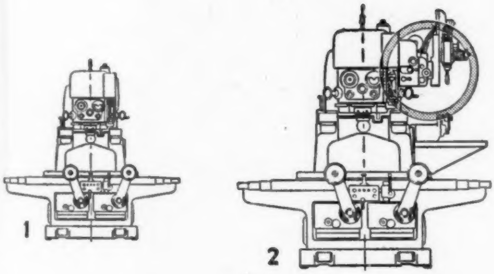

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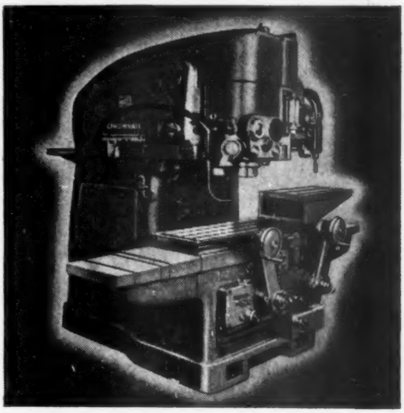

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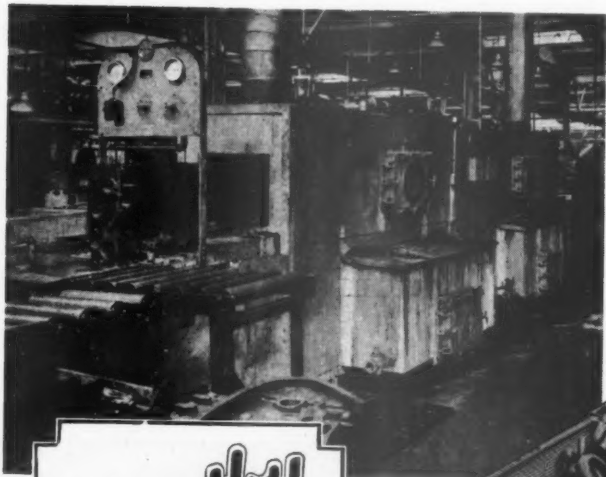
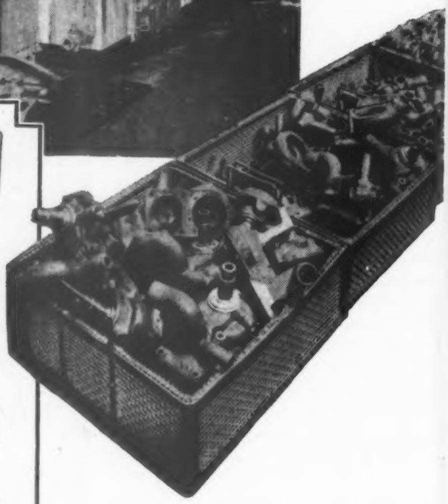


Bratby

INDUSTRIAL CLEANING MACHINES

This illustration shows a machine cleaning crank cases in the production line.

It is equally capable of cleaning small parts in baskets.



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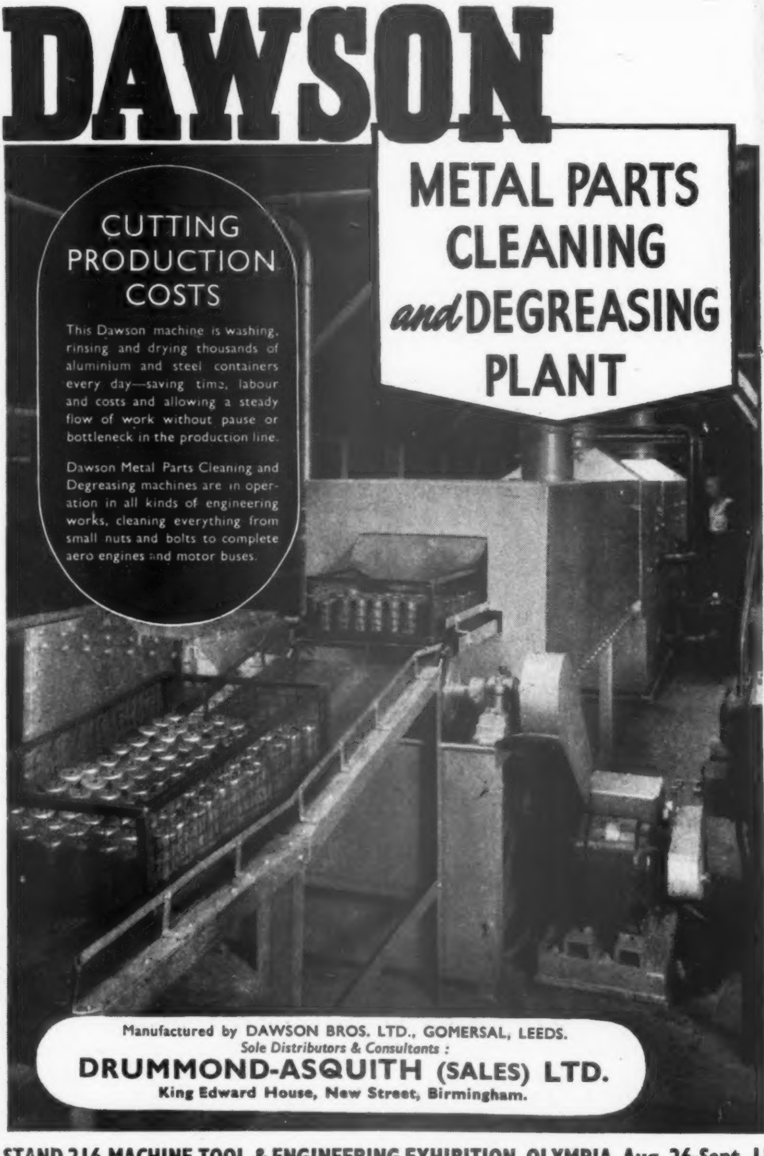

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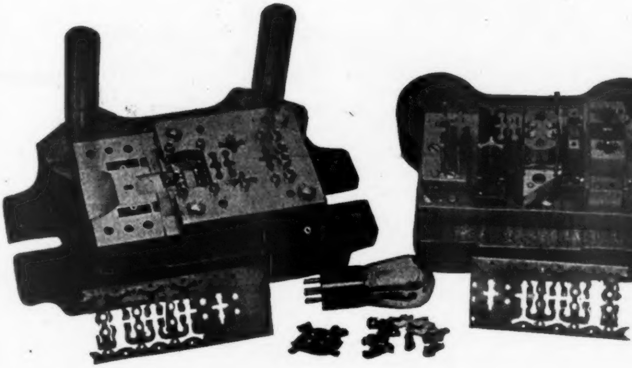

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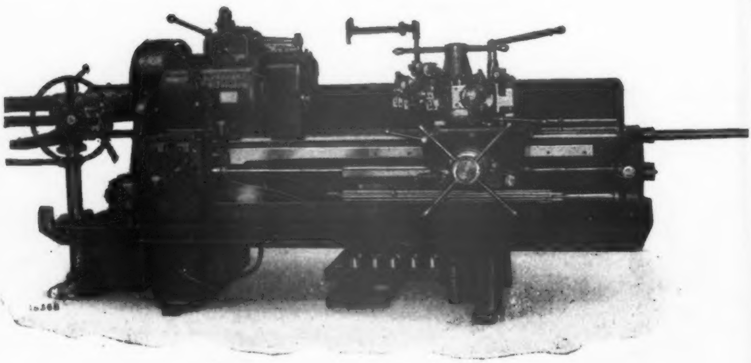

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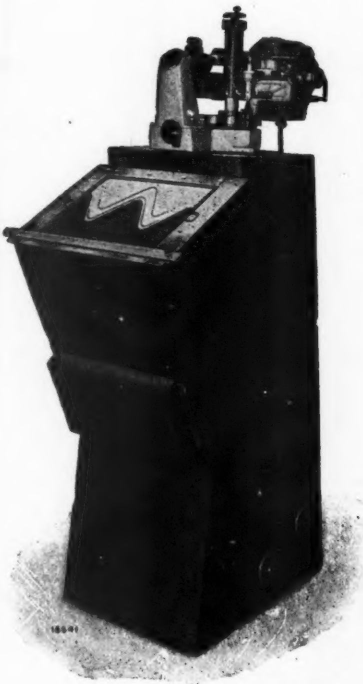

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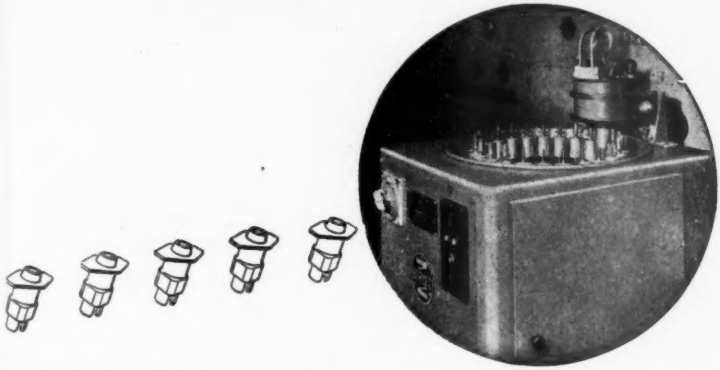

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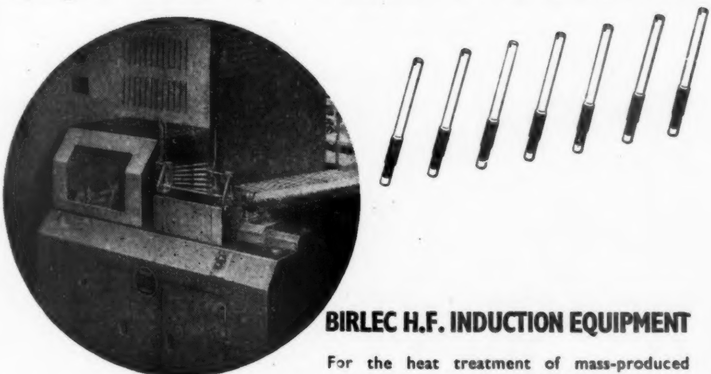

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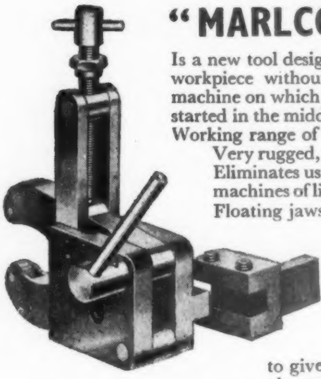

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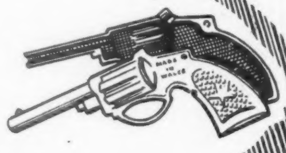

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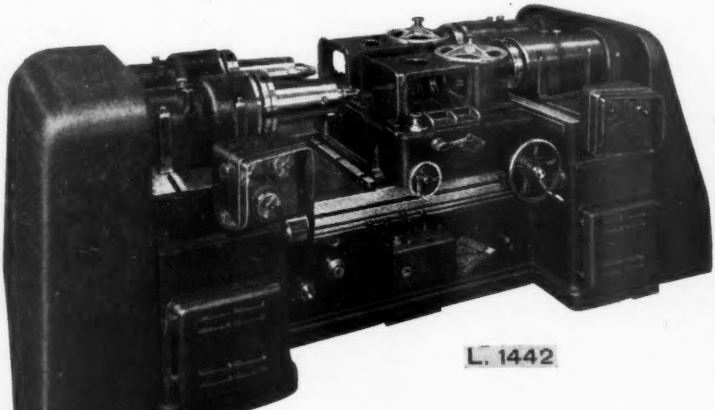

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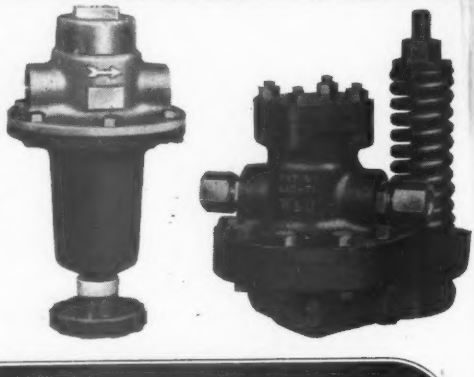

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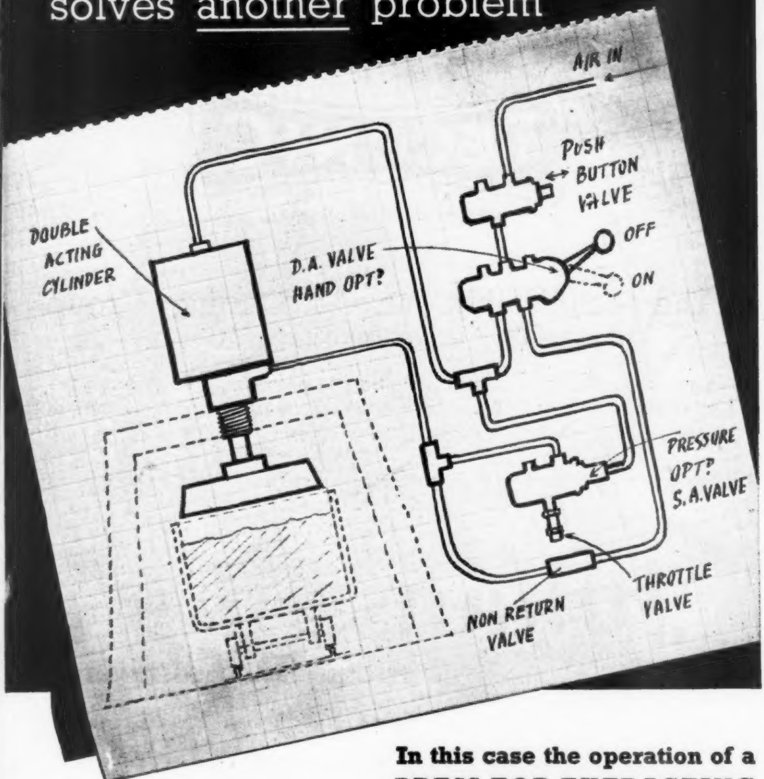

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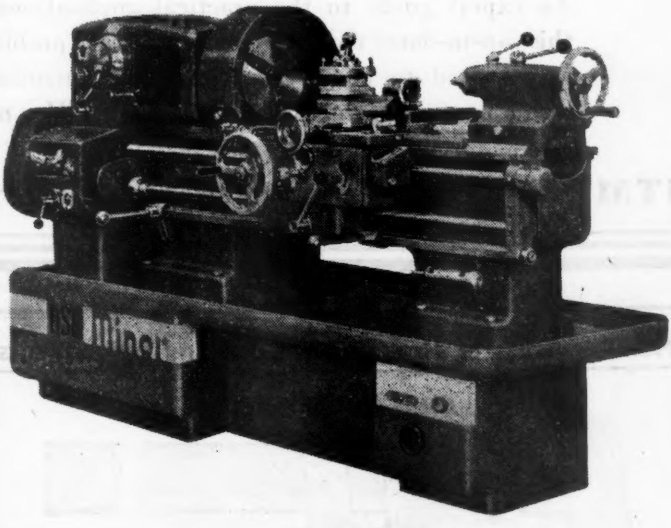

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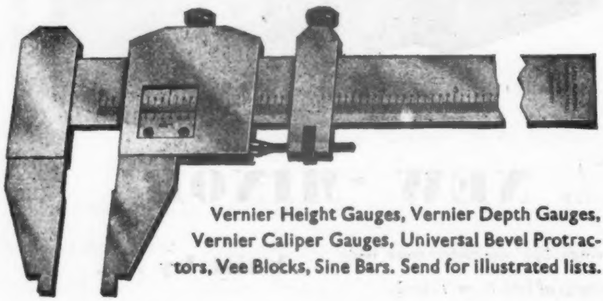

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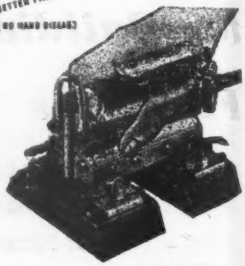

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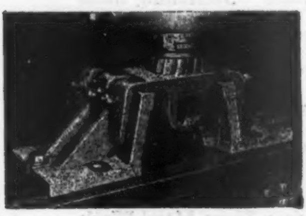

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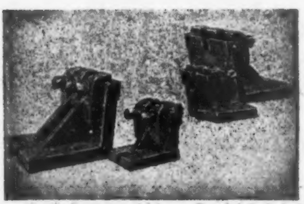

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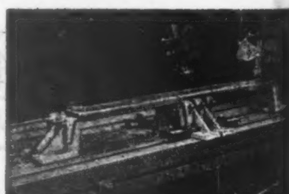

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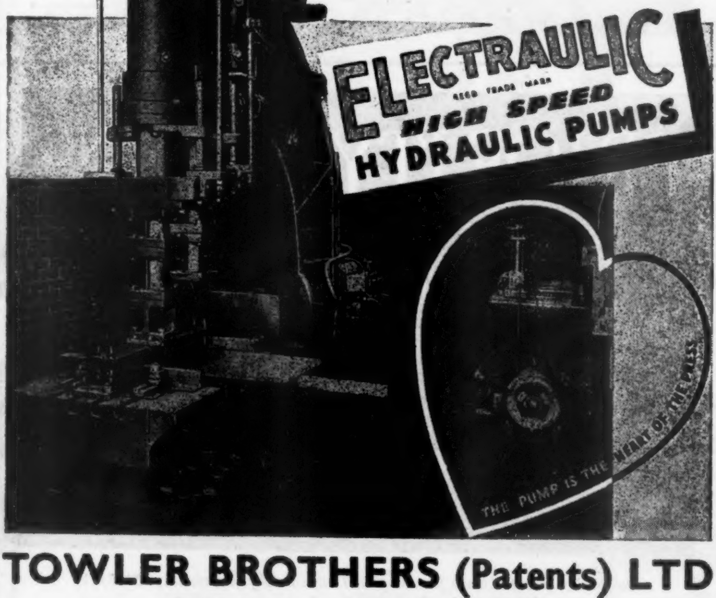
The press illustrated is a 100 ton three-ram flanging and upsetting press installed in 1942. All three rams are independently controlled — 10 tons to 100 tons — by a turn of a knob.

(Illustration by courtesy of Hunslet Engine Co., Ltd., Leeds).



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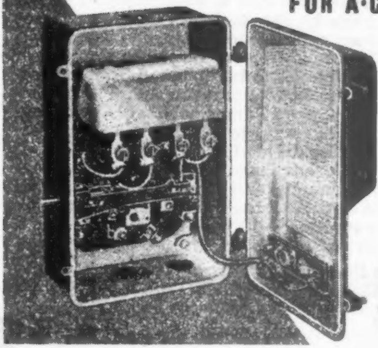

The Size I illustrated is provided with undervoltage release and three hand resetting overcurrent releases. Supplied with push-buttons in lid or for remote operation.

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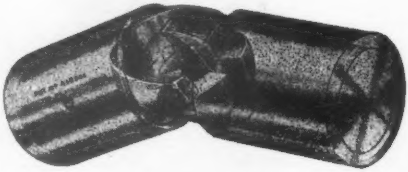

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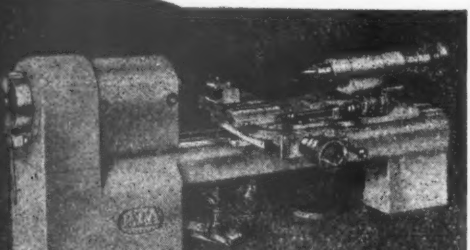

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Resistance : Up to 40 megohms.
Capacity : .01 to 20 μF.
Decibels : –25 Db. to +16 Db.
Audio-frequency Power Output : 0 to 2 watts.

Size: 8" x 7½" x 4½". **Weight**: 6½ lbs. (including leads

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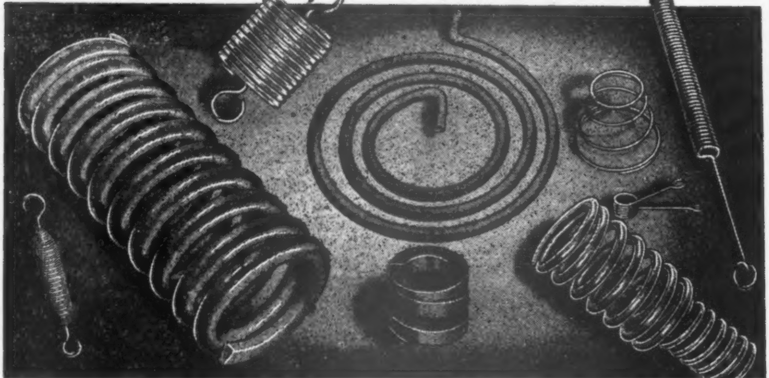

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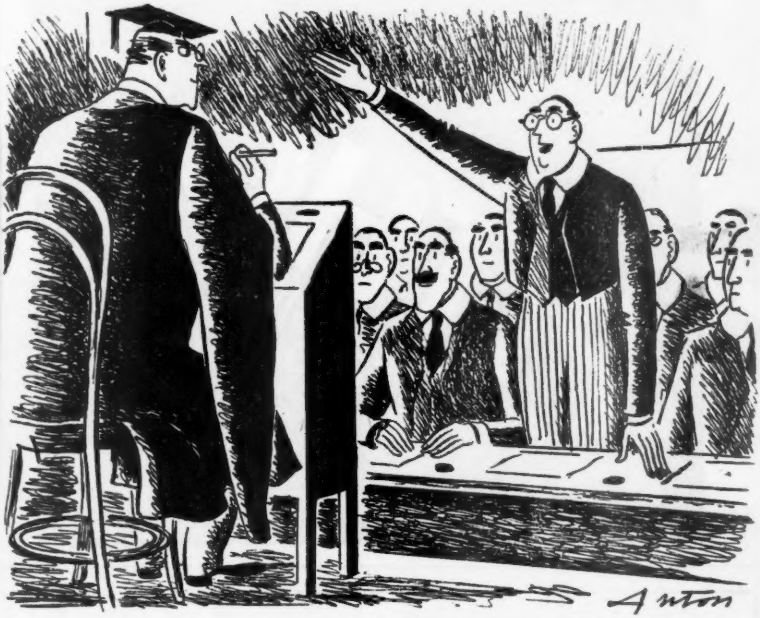

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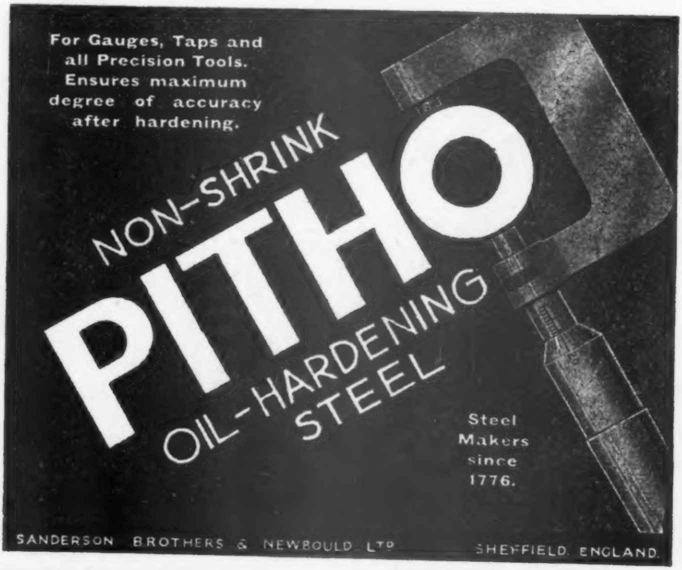
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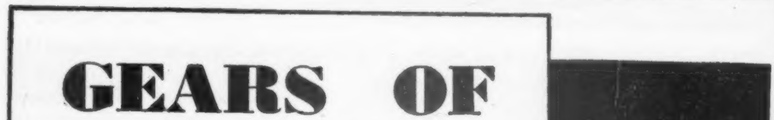
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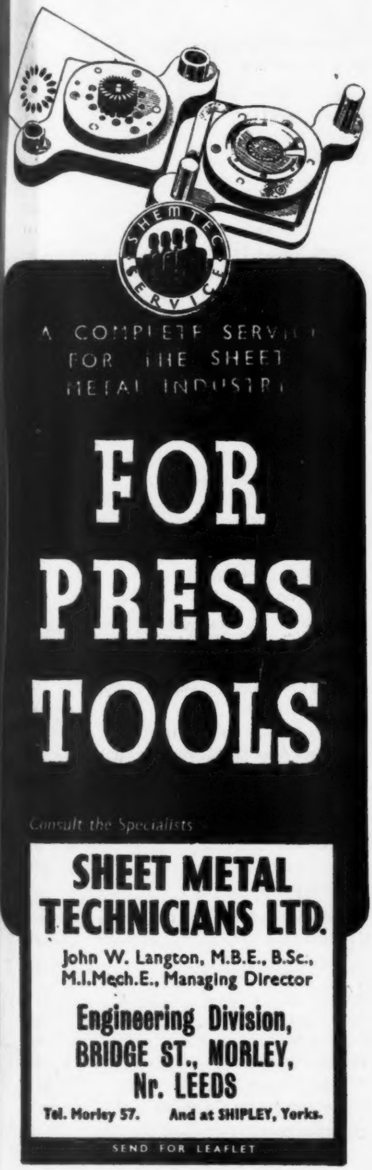
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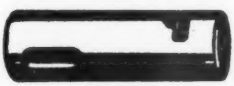

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